International Marine Engineering

JANUARY, 1907

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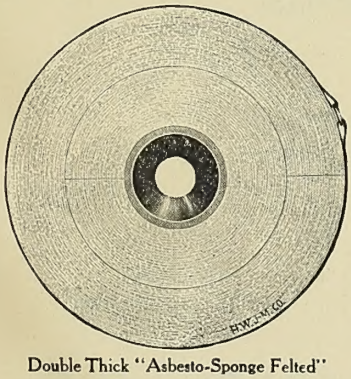

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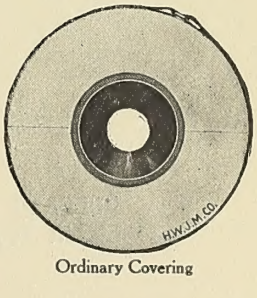

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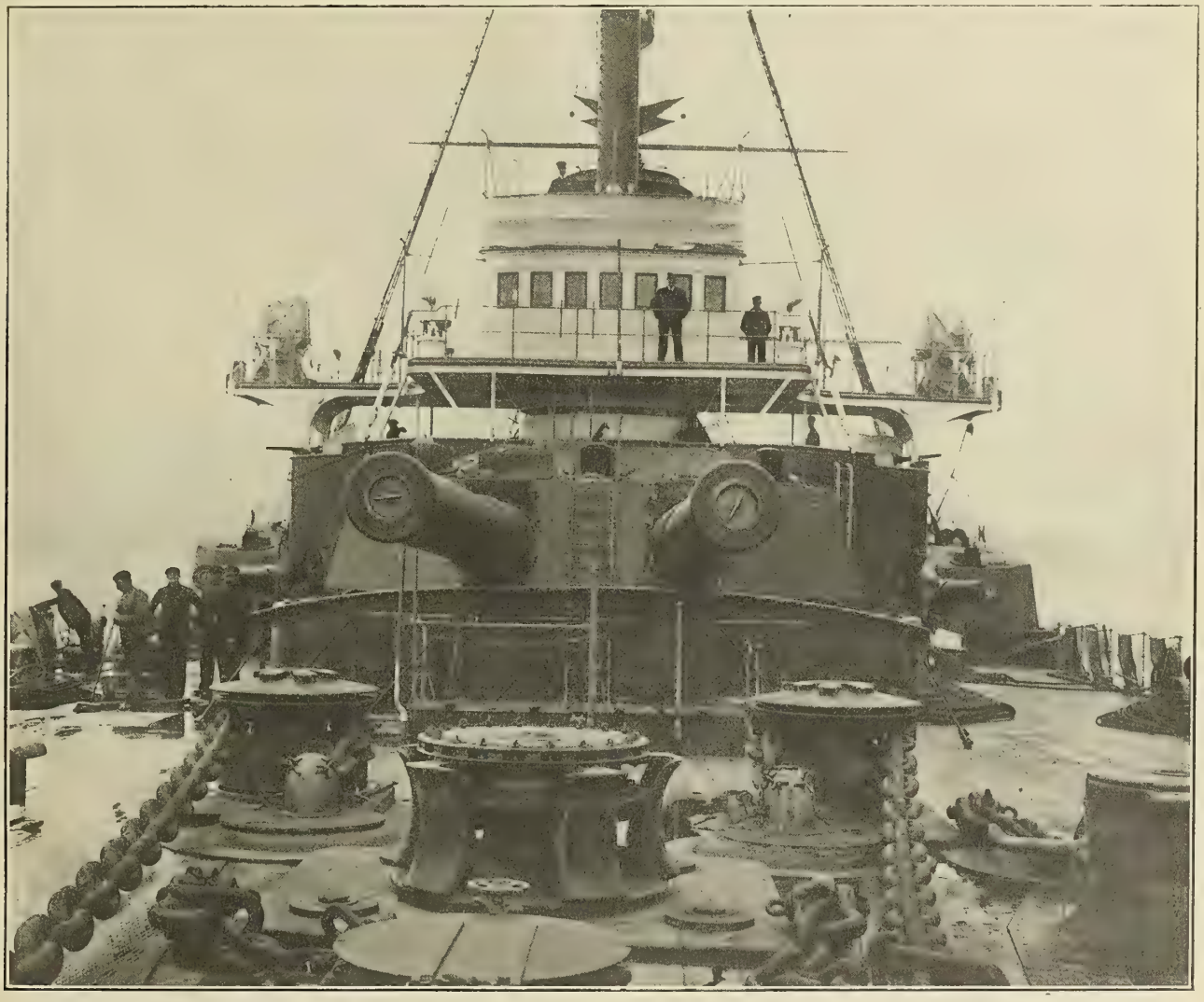
International Marine Engineering

JANUARY, 1907.

DEC 26 1906
PATENT OFFICE

THE JAPANESE BATTLESHIP KATORI.

There have been recently added to the Japanese Navy two first class battleships built in England, both on the same general lines, but differing in certain particulars. These are the *Katori,* built by Vickers, Sons & Maxim, Ltd., Newcastle-on-Tyne, and the *Kashima,* built by Sir W. G. Armstrong, Whitworth & Company, Ltd., Elswick. The differences are more or less minor in character, and the description will be confined to the *Katori.*



VIEW OF MAIN DECK OF KATORI, TAKEN FROM FORWARD, SHOWING TWIN 12-INCH RIFLES AND TWO 10-INCH GUNS.

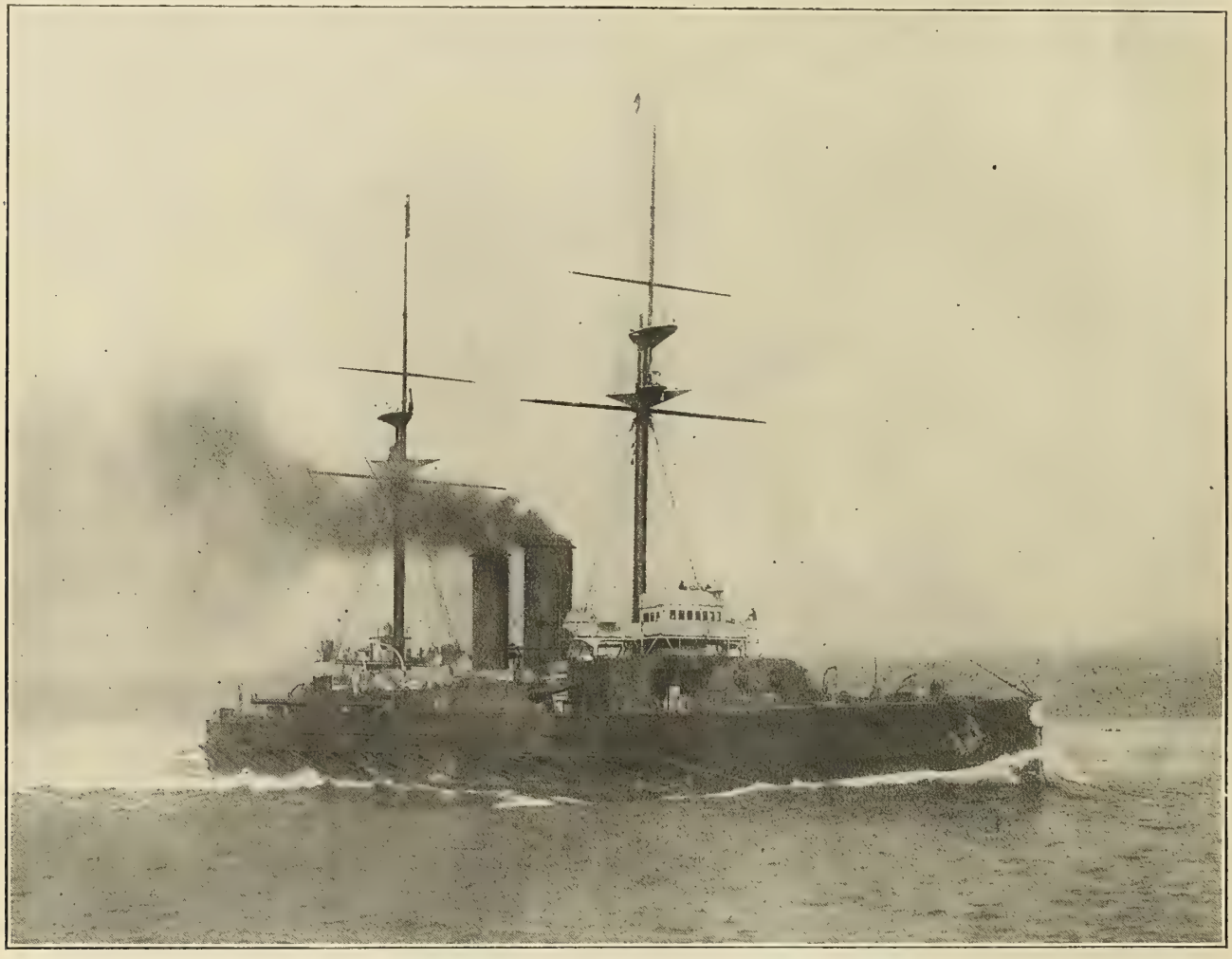
This ship has a length between perpendiculars of 420 feet; length over all, 456 feet; breadth, 78 feet; depth to upper deck, 44 feet; draft, 27 feet; displacement, 15,950 tons. The lines are especially fine, as is evidenced by the fact that her block coefficient figures out at 0.632.

The battery is a very powerful one, including four 12-inch breech-loading rifles, 45 calibers long, mounted in pairs in barbettes on the center line, with 10-inch armor protection. Four 10-inch 45-caliber guns are mounted singly in barbettes at each corner of the citadel, behind 6 inches of armor. Twelve 6-inch 45-caliber guns are on pedestal mountings, ten being on the main deck and the other two on the upper deck. Twelve 12-pounder guns have been fitted, besides a number of smaller pieces and five submerged 18-inch torpedo tubes. The larger guns are especially powerful, having muzzle energies of 48,210 foot tons for the 12-inch, 27,570 foot tons for the 10-inch and 5,830 foot tons for the 6-inch. These figures correspond with muzzle velocities of respectively 2,860, 2,820 and 2,900 feet per second. The guns weigh respectively 57.48, 35.18 and 7.32 tons.

including breech mechanisms, but not including the mounts. On the artillery trials the guns were fired at high elevations and at various positions through the arc of train; they developed no apparent injury in the structure of the ship. A 10-inch gun was fired five times in 2 minutes 8½ seconds, or at the rate of 2⅓ rounds per minute; a 6-inch gun was fired eight times in 52.4 seconds, or at the rate of 9 shots per minute.

The main armor belt has a depth of 7 feet 9 inches, of which 5 feet 3 inches is below the normal water line. This belt extends from bow to stern, the thickness of 9 inches for 240 feet amidships being reduced gradually to 4 inches at the bow and to 3½ inches at the stern. At the ends of the heavy part of the belt thwartship bulkheads of the same thickness are carried across the ship, and extend in depth from the lower to the middle armored decks. A 6-inch upper belt, extending for 185 feet amidships, covers the side of the ship from the main belt to the main deck, and is carried forward to a thickness of 4 inches. At the after end of this belt an armor bulkhead 6 inches thick is carried across the ship. Above this secondary belt, and covering the space between the 12-inch barbettes, is armor 6 inches thick to the upper deck, with oblique bulkheads carried in to meet the barbettes. The two 6-inch guns on the upper deck are protected by 4 inches of armor covering the sides of a battery 74 feet long and 7 feet 6 inches high. The backs of the 12-inch barbettes are reduced in thickness to 5½ inches, because of the protection afforded by the belt and battery armor. The lower portion of the 10-inch barbettes is similarly reduced to 2 inches. The protective deck has a thickness of 2 inches on the flat, with 3 inches on the sloping sides and 2½ inches at the ends of the ship.

The propelling machinery consists of two sets of four cylinder triple expansion engines, balanced on the Yarrow, Schlick, Tweedy, system and operating each a four-bladed propeller, 17 feet 3 inches in diameter, constructed of Stone's bronze. The cylinder diameters are respectively 35½, 56 and two of 63 inches, with a stroke of 48 inches. Steam is furnished by twenty Niclausse boilers located in three separate boiler rooms, five of the boilers having sixteen sections and the others each fifteen sections. Each section consists of twenty-four tubes. The total heating surface is 44,000 square feet and the grate area 1,334 square feet, the ratio being 33 to 1. Steam is furnished the engines at a pressure of 200 pounds per square inch, the boiler pressure being 230 pounds. There are four condensers, with a total cooling surface of 17,000 square feet. The two funnels measure 90 feet above the grate bars. The forward one is 12 feet 9 inches in diameter over the casing, while the aft one is of an elliptical section, 12 feet 9 inches fore and aft and 8 feet 1 inch in the minor axis.



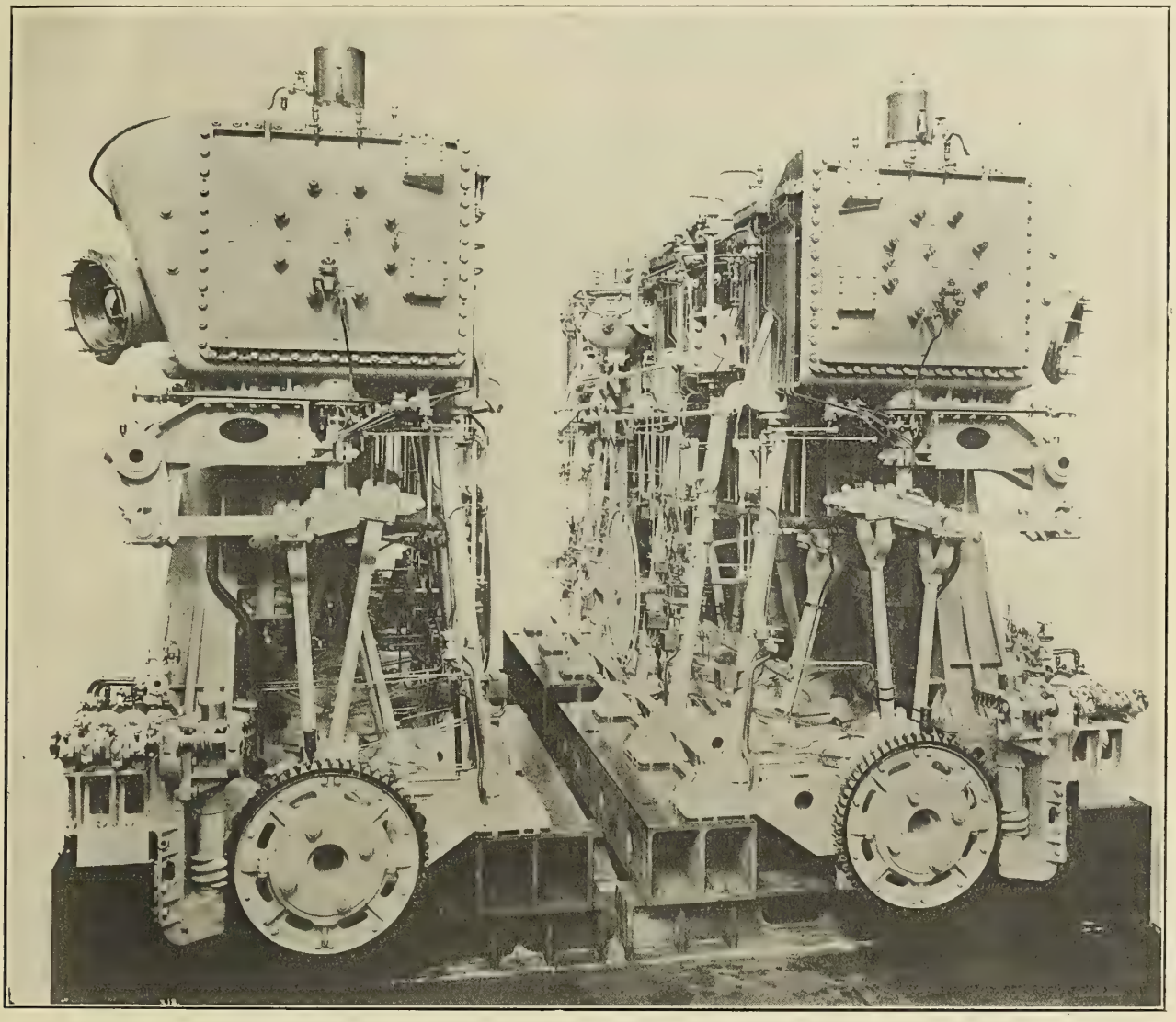
THE BATTLESHIP KATORI STEAMING AT 20 KNOTS ON OFFICIAL TRIAL TRIP.

Steam trials of this vessel at reduced power gave 17.8 knots with 1.6 pounds of coal consumed per indicated horsepower per hour. Four runs over a course ten miles long gave an average speed of 20.22 knots, with engines operating at full power, and at about 130 revolutions per minute. The normal coal supply of 750 tons can be increased to a total of 2,100 tons.

The main engines, of which we present a photograph, are fitted with piston valves on the high-pressure and intermediate cylinders, and with double-ported flat slide valves on the low-pressure cylinders. All the valves are operated by means of the Stephenson link motion. The engines are designed to turn the propellers inboard when going ahead, and the starting platform

is in the center of the ship. It will be seen that the cylinder supports are in the form of wrought steel columns in front, and of the ordinary cast iron A-framing in the rear, ample slipper guide surface being provided on the latter. The cylinders themselves are in each case independent castings.

The vessel is lighted throughout by electricity and is ventilated by electrically driven fans. The thermo-tank system of ventilation has been adopted for the cabins and crew spaces, and the displacement being 16,400 tons. The normal coal supply is 750 tons, which may be augmented to 2,150 tons. The four-cylinder triple expansion engines have cylinders 36, 56 and two of 63 inches in diameter with a 48-inch stroke. The contract requirement for speed and power called for 18½ knots at 15,600 indicated horsepower. The coal consumption of the *Kashima* turned out to be 1.86 pounds per horsepower per hour at 18 knots and 2.12 pounds at full speed.



MAIN ENGINES OF THE JAPANESE BATTLESHIP KATORI, AS ERECTED IN THE BUILDERS' SHOP.

for cooling the magazines and shell rooms. The living quarters are provided with a complete system of steam heating. The usual equipment of steering engines and gear, electric generating plant, refrigerating machinery, air compressors and other auxiliaries are naturally of the latest types, and all have given complete satisfaction in service.

The trials of the sister ship *Kashima* were carried out in such manner that progressive speed results can be tabulated as follows:

Revs. per minute.	I. H. P.	Speed, knots.
69.5	3,030	11.136
89	6,275	14.27
102	9,160	16.323
110	11,400	17.204
113.6	13,000	18.
123	17,280	19.242

The *Kashima* is 425 feet between perpendiculars, 78 feet beam, 43 feet 6 inches deep and has a mean draft of 26 feet 7½ inches,

Obituary.

J. D. Ellis, of Sheffield, England, died November 11, at the age of eighty-two. Mr. Ellis was prominently identified with armor plate manufacturing, and was the inaugurator of the Ellis & Eaves system of induced draft, designed to improve combustion and reduce the production of smoke. For the past thirty-five years he has been chairman of the Sheffield works of John Brown & Company, and has seen the firm increase in its operations to such an extent that the original 250 workmen now number more than 16,000.

Sir Edward James Reed, M. P., who was chief constructor of the British navy from 1863 to 1870, died November 30, at the age of seventy-six. He was one of the most distinguished authorities on shipbuilding and naval design in the world. He was the author of a variety of works on shipbuilding, all of which were regarded as authorities. He has been repeatedly honored by appointments under the government, and in many other ways, having been made a K. C. B. in 1880.

Launch of the New Wilson Liner Oslo.

There was launched April 9, 1906, from the yard of Earle's Shipbuilding and Engineering Company, Limited, Hull, a handsomely modeled steel screw steamer, built to the order of Thomas Wilson Sons & Company, Limited, Hull, for their passenger and cargo trade between Hull and Christiania.

The dimensions of the ship are: length, 290 feet; breadth, 39 feet; depth molded, 20 feet. She is built to the British Corporation Registry's highest class, with cellular double bottom all fore and aft, and fore and aft peaks arranged for water ballast. She has two pole masts of steel, complete awning deck and topgallant forecastle. There are three holds for cargo, and 'tween decks forward are arranged for either cargo or third class passengers.

The vessel has silent steam steering gear of Amos & Smith's special design, steam windlass, and a complete installation of electric light. For the rapid discharge of cargo there are four powerful steam winches. A system of fire extinguishing pipes is fitted to each cargo space.

Passenger accommodations will be provided as follows:

69 first class passengers in 1 and 2 berth cabins.
32 second class passengers in 4 berth cabins.
90 third class passengers in 6 berth cabins.
410 third class passengers in 'tween decks forward.

The first class state rooms are placed amidships under the awning deck. The principal rooms, consisting of dining saloon, library and smoke room, are placed in deck houses amidships. Access to these rooms has been so arranged, by means of inside stairways, that in rough weather the passengers may reach either of them without being exposed.

The second class state rooms are placed under the awning deck and the dining room is in a deck-house at the after end of engine casing.

The third class accommodation is placed in the 'tween decks forward and aft, and all fittings for these are of the latest improved type.

The officers and engineers are berthed in the midship deck-house. The firemen are placed in the 'tween decks alongside the engine casing, and the seamen are berthed in the forecastle.

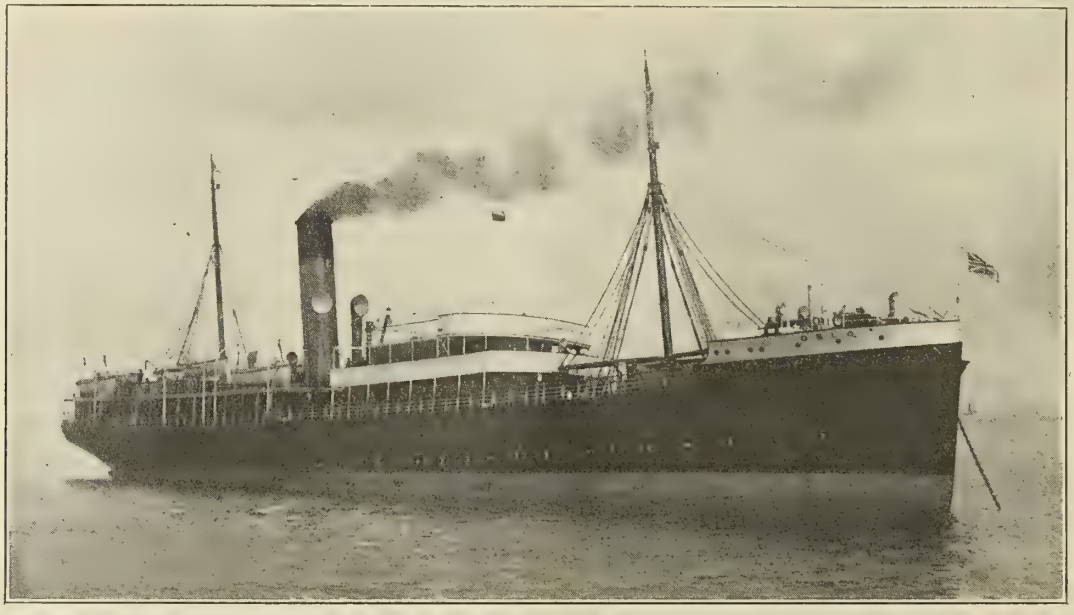
The accommodation throughout the vessel has received the careful attention of both owners and builders, so that the maximum degree of comfort will be secured to all classes of passengers. Special attention has been given to all sanitary and heating arrangements.

The ship has been fitted with triple expansion surface condensing engines, having cylinders 22, 36 and 60 inches in diameter by 42 inches stroke, supplied with steam by two large single ended boilers, working at a steam pressure of 180 pounds per square inch, and fitted with forced draft.

Oslo, originally spelt Opslo, was founded in 1050 by King Harald Sigurdson, known to history as Harold Haardraade (Hard Ruler), who invaded England and was defeated and killed at Stamford Bridge in 1066 by Harold II.

Oslo was destroyed by fire in 1624, and rebuilt by Christian IV of Denmark, from whom the city derived its name.

James Fisher.



NEW WILSON LINE STEAMER OSLO, FOR SERVICE BETWEEN ENGLAND AND NORWAY.

The New English Torpedo Launch Dragonfly.

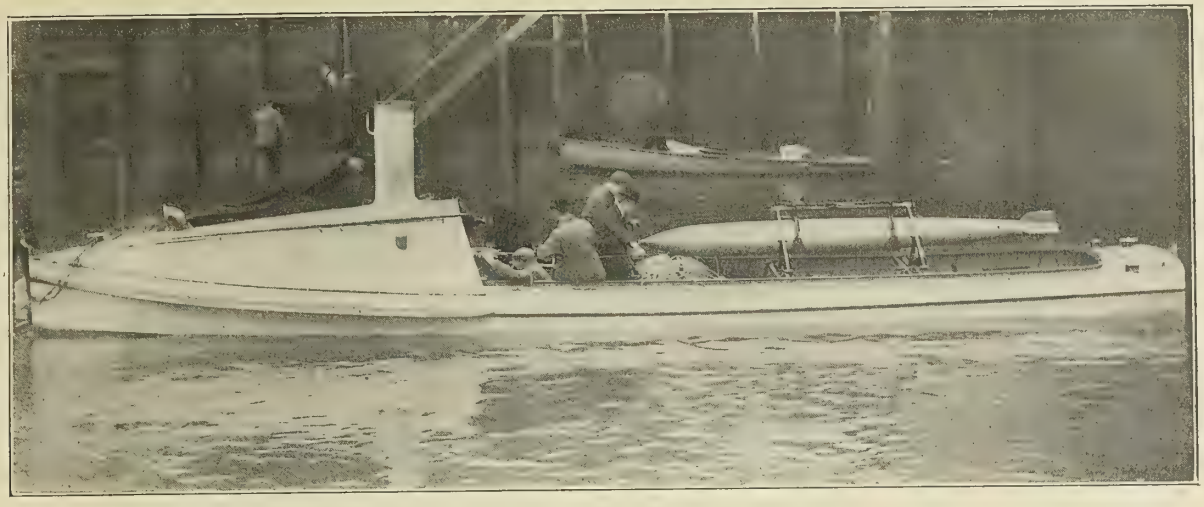
A forty-foot torpedo launch recently built in England is a most interesting craft, having been designed to operate at a speed of 18 knots. The *Dragonfly* is constructed to carry a 14-inch Whitehead torpedo, which is to be lowered over the side by means of a specially designed side drop gear. The body is first directed bow-on in the direction of the object which it is desired shall be destroyed, and then launched.

This torpedo boat is propelled by a 120-horsepower gasoline engine, and is of 8,500 pounds displacement, with a draft of 2 feet 7 inches and a beam of 6 feet 2 inches. The boat is built of galvanized mild steel, and is provided with a watertight collision bulkhead. It has a very broad stern, which is said to overcome any difficulty as to stability when launching the torpedo over the side.

The accompanying illustrations show the arrangement of the torpedo on the craft, and the turtle back deck, which is arranged in the bow extending to the rear as far as the after end of the engine, this being a portable piece carried over the engine to protect it from the weather. Detachable spray guards are so placed as to prevent the splash from the bow waves being carried aboard.

The steering wheel and reversing lever are located on the port side. The engine is supplied with fuel from a tank which holds 100 gallons of gasoline, enough fuel it is claimed to operate the launch for a period of ten hours.

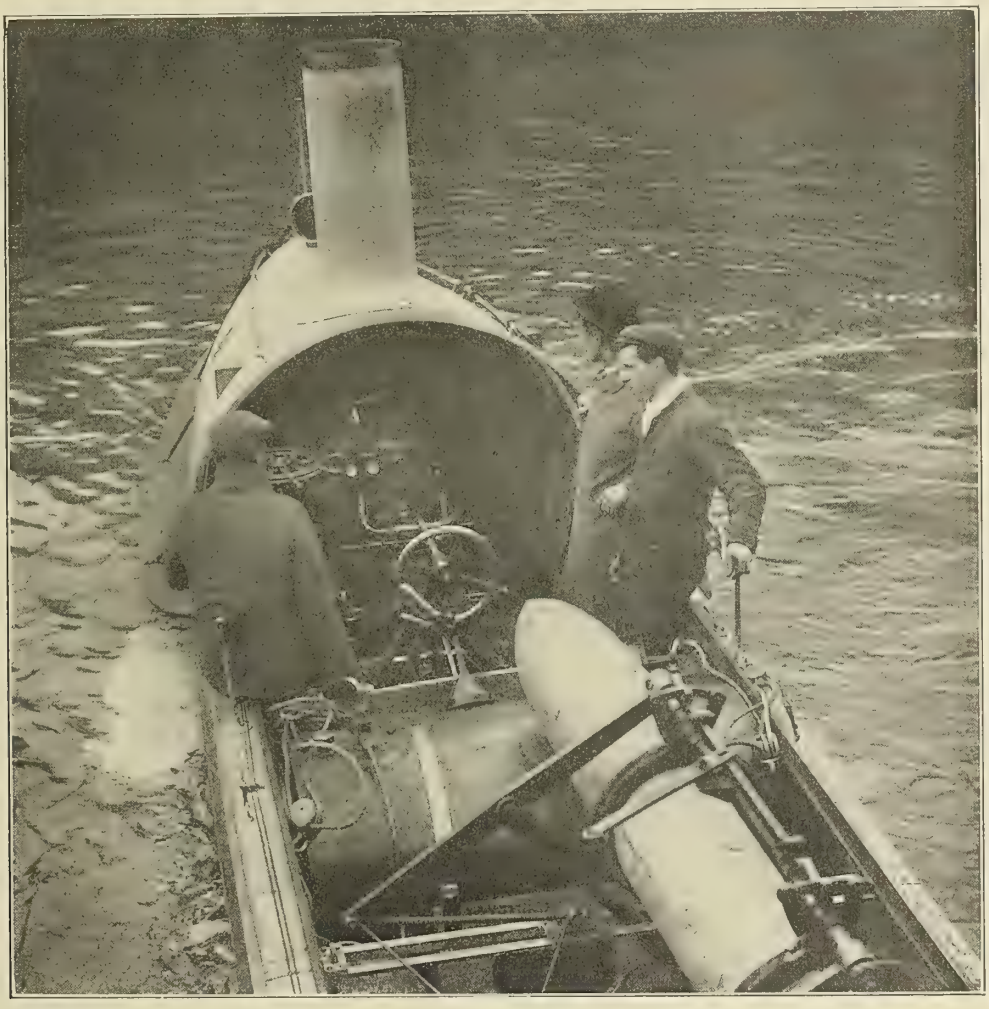
The *Dragonfly* is equipped with a four-cylinder engine which operates at a speed of 900 revolutions per minute. The cylinders are of 8-inch bore and a stroke of 8 inches. The engine weighs about 2,500 pounds, which is at the rate of 23.25 pounds per



MOTOR-PROPELLED TORPEDO LAUNCH DRAGONFLY, CONSTRUCTED IN ENGLAND.

brake horsepower. It is maintained that there is very little vibration, even at the speed of 900 revolutions per minute, the engine being of very light construction and very carefully and exactly balanced as to its moving parts. This is most essential, in fact absolutely necessary, on account of the very light construction of the hull, in order to insure high speeds and effectiveness in service. The engine is started by means of compressed air contained in a reservoir placed in the stern of the launch. A small Brotherhood compressor is provided for supplying the necessary air pressure, driven by a Thornycroft single cylinder oil engine of 6-horsepower capacity.

The *Dragonfly* was constructed at the shops of John I. Thornycroft and Company, Limited, Chiswick, near London, where recently very interesting marine gas producer outfits were constructed and installed in the launches *Emil Capitaine* and *Duchess of Chiswick*.



INBOARD VIEW OF THE DRAGONFLY, SHOWING TORPEDO LAUNCHING GEAR.

COLD STORAGE ON BOARD SHIP.

BY SYDNEY F. WALKER, M. I. E. E.

FAULTS.

The term faults, which is a very good one, is borrowed from the practice of electrical engineers, who refer to a fault in a cable, when the insulation has been damaged, and possibly the current refuses to pass the damaged spot in sufficient quantity to work the apparatus beyond; or to a fault in the armature of a dynamo, when the insulation has been destroyed, and the armature refuses to furnish its proper pressure, and so on; and the term is used in the same sense in these articles. Faults are causes of failure, things which happen, and which prevent apparatus from working properly.

There is nothing in cold storage apparatus that the marine engineer who knows his work will not be able to master, if he puts his mind into it, and if he will remember the differences between the freezing apparatus and the steaming apparatus. There is a great similarity between the two in many respects, and on the other hand, there are some very wide and important differences that must be remembered, if the plant is to be kept going satisfactorily. A cold storage plant is very much in the nature of a steam plant reversed. The cold store itself, or the brine tank, or the air cooling apparatus, or whatever may receive "cold" from the expansion coils, stands very much in the same relation to the whole plant as the boiler does to the steam plant.

The refrigerating agent, carbonic acid or ammonia, enters the expansion coils—the "refrigerator" as it is now more common to call it—as a liquid, and there becomes vapor or gas. The vapor or gas passes from the expansion coils to an apparatus, very similar in every respect to a steam engine, even to the fact that it is often divided into two, the process being compounded, but there is the important difference that instead of the refrigerant driving the piston, the piston drives it, compressing the gas or vapor, preparatory to its being recondensed into the liquid form. Again the gas or vapor passes from the cylinder of the compressor to the condenser, where very much the same thing happens as when steam is condensed to water. The gas passes through pipes, over which cooling water is driven, the cooling water extracting the latent heat from the gas, and reducing it again to a liquid. But again there is an important difference. With the cold storage condenser there is no air pump. Air must on no account be allowed to enter the refrigerating system. As will be explained later, its presence seriously lowers the efficiency of the apparatus, and one of the most important things the "freezer" engineer has to look out for, is that air shall not get into the system. The presence of air also reduces the work the plant will do, the "heat it will lift."

Again, one of the earliest things the steam engineer gets knocked into him by practical experience, and one of the things that the experienced engineer looks out for almost before anything, is leakage. It may be fairly said that no engineer in charge of a steam plant can run it economically who has not a "nose for a leak." The steam engineer learns to know that leakage of steam means waste. But with refrigerating apparatus, leakage of the refrigerating agent means very much more than it does in the case of a leakage of steam. A leakage of steam can be made up, providing it is not too great, by increased generation of steam from the boiler. It is merely a nuisance, as it tends to increase the leakage path, and to make a mess in its neighborhood, but beyond that it merely means an increased quantity of coal, and possibly water consumed. But with a cold storage plant, leakage of the refrigerant means, and very quickly, a largely reduced efficiency of the system; and other troubles.

The necessary number of heat units that are to be extracted from the brine, the air, or the room, and from the produce itself, are absorbed by the conversion of a definite quantity of the refrigerant, carbonic acid or ammonia, from the liquid to the gaseous condition, and this is possible only if a certain quantity of the liquid is present, and is allowed to pass through the expansion valve in each unit of time, or at each stroke of the compressor. If the system is short of refrigerant, as it will be if a leak is allowed to be set up, the requisite quantity of liquid is not available, and the refrigerant passes through the expansion valve, partly as a liquid and partly as a gas. The difference between the cooling properties of the refrigerant, as a gas and as a liquid, is enormous. Every pound of liquid ammonia that is converted into gas absorbs in the neighborhood of 500 heat units in the process, while every pound of carbonic acid absorbs in the neighborhood of 120 heat units, but the pound of ammonia gas or carbonic acid gas passing through the expansion coils in place of the liquid, will absorb less than one-half of one heat unit. Hence the importance of keeping the proper charge of the refrigerant present in the system is at once apparent.

In addition to that, as marine engineers are aware, when ammonia or carbonic acid is able to leak out, air is able to pass in when the plant is standing. The quantity of air passing in in any given time may be small, but every engineer knows the enormous effect of the continued passage of a very small quantity of some troubling agent, and everyone who has had to do with pumps is aware of the trouble caused by the ingress of air. In the refrigerating system the entrance of air operates in two ways. The space occupied by the air is at the expense of a certain quantity of the refrigerant. In addition, air cannot be liquefied. It becomes heated under compression. It is apt to collect in parts of the system, again in a compressed and heated state, and generally to give trouble.

One of the first rules therefore to be observed by the marine engineer who takes charge of a refrigerating apparatus is to keep a very careful eye upon all joints, stuffing boxes, glands, etc. Where the pipes carrying the gas enter the condenser, and where the liquid leaves it, the glands through which they pass must be maintained absolutely gas-tight. And perhaps a more important matter is the question of leakage of the refrigerant in the neighborhood of the piston rod. In the case of the steam engine a little steam passing up by the side of the piston rod does very little harm, but in the case of refrigerating apparatus, the passage of the refrigerating agent along the piston rod, and so to the atmosphere outside, has very serious results indeed, as will be explained later on.

One of the difficulties in the way of finding leaks of carbonic acid or ammonia lies in the fact that they do not render themselves visible, as steam leaks usually do, by condensing. Carbonic acid gas may be leaking into the atmosphere in the neighborhood of the compressor, or at other parts of the apparatus, for a very long time, and nobody will know it, except by its effect upon the working of the cold storage plant. Carbonic acid gas is a poison, in the sense that when it is present in certain definite quantities, animals are unable to breathe, but in the ordinary engine room, where there is a certain amount of ventilation, there may be a comparatively large leak of carbonic acid gas, carried off by the ventilating air current, without any danger to anybody, and without any effect, even in extreme cases, beyond a headache. Ammonia gas is more easily detected by its pungent odor, but even ammonia gas may be escaping in small quantities, and be carried off, unnoticed, by the ventilating air current, and be creating a considerable shortage in the system, without anybody suspecting it.

For carbonic acid gas the rule is, to cover joints and all places where leakage may take place, with soap and water. If there is a leak, soap bubbles are formed. With ammonia the nose is usually a very good apparatus for testing, but if a more certain one is required, a piece of sulphur held on the end of a stick and lighted, the burning sulphur being held in the neighborhood of joints where leaks are suspected, will show their presence immediately by creating dense white fumes.

WATCH THE GAGES.

In this matter the marine engineer will recognize the similarity with his work, in connection with steam plants. Just as he watches

the steam gage and the water gage on his boiler, so his success in keeping his refrigerating plant in good order depends largely upon his watching the gages upon the different parts of the apparatus. The gages in connection with a refrigerating plant have also a greater importance, even, than in connection with a steam plant. An intelligent interpretation of the gages will tell a good deal of what is going on in the refrigerating plant, and will enable the proverbial stitch in time to be put in. Steam engineers are familiar with the fact that each steam pressure corresponds to a certain temperature of the steam, and the same thing rules with the carbonic acid and ammonia employed in refrigerating plants. Each pressure corresponds to a certain temperature.

It is usual to place gages marked in pressures and the corresponding temperatures on two eccentric circles on what are termed the high-pressure and low-pressure sides of the plant. It will be remembered that the carbonic acid or ammonia comes into the compressor in the form of a gas, and is compressed and delivered to the condenser at a considerably higher pressure. The condenser is therefore the high-pressure side, and the gage is usually fixed at the entrance to the condenser. The liquid, it will be again remembered, passes through the expansion valve, or regulator, as it is often called, into the expansion coils or refrigerator, and is there reconverted into gas with a corresponding fall in pressure from that at the entrance to the condenser. This side, therefore, is the low-pressure side. The low-pressure side may be taken to be that portion of the apparatus between the regulator and the suction valve of the compressor; while the high-pressure side is between the delivery valve of the compressor and the condenser side of the regulator. It is usual to place another gage on the suction side of the expansion coils, marked also in pressures and the temperatures corresponding.

It will be noted that the reverse of steam apparatus mentioned above is maintained here, the entrance to the condenser with steam is the low-pressure side, while it is the high-pressure side with refrigerating apparatus. The pipe through which the newly created vapor issues in the steam plant is the high-pressure, whereas it is the low-pressure in the refrigerating plant. In all refrigerating plants there are certain standard pressures that are maintained under ordinary conditions, at the entrance to the condenser, and at the exit from the expansion coils. The pressure at the exit from the expansion coils is not reduced to nothing, as might be at first supposed. In fact, a little consideration will show that, other things being the same, the pressure on the suction side of the compressor is all the better for being higher. With high suction pressure there is less work for the compressor to perform than where the suction pressure is low, and therefore less coal, steam, etc., is consumed in compressing the carbonic acid or ammonia.

The ordinary standard pressures are for carbonic acid 65 to 75 atmospheres, or 955 to 1,100 pounds per square inch at the entrance to the condenser, corresponding with 76° to 86° F., and 25 atmospheres, or 367.5 pounds per square inch at the exit from the evaporating coils, corresponding to 10° F.; with ammonia, from 160 to 180 pounds condenser pressure, and about 15 pounds suction pressure, are the standard. The above pressures and temperatures are for cooling water at 60° initial temperature, or thereabouts, on entering the condenser. Where cooling water of a lower temperature is available, say at 40° or 50° F., the condenser pressure may be lower, and, on the other hand, where the only cooling water available is at a higher temperature, the condenser pressure also must be higher.

It was mentioned above that it is an advantage to keep the suction pressure high, within certain limits. It is also an advantage to keep the condenser pressure as low as possible, also, of course, within certain limits. The reason will be immediately apparent. The work done in lifting the heat from the cold chamber and delivering it to the sea is performed partly in the compressor, and partly by the circulating pump; therefore it is obvious that the less work both the compressor and the circulating pump have to do, the less coal must be burned, and the cheaper is the storage produced. With low condensing pressure it is evident that less work has to be done by the compressor piston upon the gas coming over from the evaporator coils, than with the higher pressure. Also, as already explained, the higher the pressure at which the gas comes over from the evaporator, the less work the compressor has to perform in compressing it to a certain figure. It will be understood that a certain condenser pressure is necessary in all cases, before the gas can be converted to the liquid state, and the lower the temperature of the gas, that is to say, the lower the pressure at which the cooling water will handle it, the less work has to be done upon it. Further, the colder the circulating water, the smaller the quantity that has to be passed through the condenser to extract a certain quantity of heat from the hot refrigerating gas, and, therefore, the less work has to be done by the pump. Condensation, it will be remembered, means the extraction of a certain definite quantity of heat from the refrigerant.

The rule in connection with the condenser pressure is, the pressure must be that which corresponds to a temperature 10 degrees above that of the cooling water at its exit from the condenser. The rule for the pressure at the suction side of the compressor, the exit from the refrigerator, is, the pressure should be that corresponding to a temperature 10 degrees below that of the brine in the brine tank, where the expansion coils are made to cool brine, and are not made to act directly upon the air of the cold chamber. When the expansion coils act directly, either upon air that is being circulated through the cold chambers, or upon the air of the cold chambers themselves, the rule is, the pressure at the exit of the expansion coils should be that which is equivalent to a temperature 20 degrees below that of the air the coils are cooling.

If the pressures named, with allowance for the variation in the temperature of cooling water, are shown on the condenser and on the evaporator, it is probable that everything is working properly. At any rate, it may be taken almost as an axiom, that when the proper condenser and evaporative pressure are showing, the compressor, condenser and evaporator are working satisfactorily, and if there is any fault, it is in the chamber itself, or in the brine circuit. It is for this reason that the writer so strongly urges the rule, "watch the gages." The "freezer" engineer will watch his gages, allowing for the increase in the condenser pressure as he passes into a warmer climate, and again allowing for the decrease of pressure as he passes into a colder climate, and will know at a glance that everything is all right up to a certain point, or the reverse, just as he does by looking at the gages on his steam boiler, etc.

There are certain signs which show whether things are working satisfactorily, in addition to the gages. The gas in the compressor is heated in the act of compression, and therefore the pipe through which it makes its exit from the compressor to the condenser is slightly warm with ammonia, and fairly hot with carbonic acid. On the other hand, the gas which is returning from the expansion coils to the compressor is expanding during the whole of its passage, and is extracting heat from everything in its neighborhood, and it therefore follows that the suction pipe leading to the compressor, and generally the whole of the compressor in the neighborhood of the suction valve, becomes covered with snow. The suction pipe and the suction valve, being cooled by the expansion of the gas inside them, cool the atmosphere in their immediate neighborhood, this resulting in the deposit of some of the moisture previously carried by the atmosphere, in the form of water, upon the pipe, valve, etc., the moisture being immediately frozen. The compressor itself should be cold. When the delivery pipe from the compressor is in the condition named, respectively, with carbonic acid or ammonia, and the suction pipe is covered with frost, things are

usually going all right, so far as the refrigerating plant is concerned, apart from the insulation of the chamber. If the delivery pipe from the compressor becomes warmer than it should be, or if it becomes cold, and again if the frost disappears from the suction pipe and the neighborhood of the suction valve, or if the compressor becomes hot, these are signs that something is wrong.

IF THE DELIVERY PIPE BECOMES HOT.

If the delivery pipe becomes hot, it is a sign that the liquid refrigerant is not passing through the regulator valve as rapidly as it ought to be, there being an increased pressure in front of the gas that is coming from the compressor, and therefore increased heat. If at the same time the frost either wholly or partially disappears from the suction valve of the compressor, it is usually a sign that the regulator valve is not open sufficiently wide. Sufficient liquid is not passing through the system to do the work required of it, and the remedy is to open the regulator valve a little wider. The regulator valve is a very delicate part of the apparatus, and it will be understood that a very small turn, either to open or close, has a comparatively large effect upon the delivery of liquid to the expansion coils.

On the other hand, the effect of either opening or closing the regulator valve, more or less, is not apparent for several minutes. If the delivery pipe remains hot after the regulating valve has been opened wide, it is a sign that there is not sufficient refrigerant in the system. The cooling effect on the compressor, the suction valve, etc., and later on the delivery valve, is due to the continuous evaporation of the liquid, that is going on right from the regulator valve into the compressor. As will be seen later, it is most important that the compressor shall be maintained cool.

If there is not the proper quantity of the refrigerant in the system, as explained above, it not only lowers the efficiency of the system, but it tends to upset the working of the system generally. A little consideration will show this very clearly. The condenser performs two offices. It is a reservoir of the liquid refrigerant, and a condenser of the gas into the liquid state. Its office as a reservoir is often assisted by a receiver, into which the liquid is passed after leaving the condenser; and, where a ship is much in the tropics, it is a wise plan to employ a receiver, and it is also wise to arrange to cool the liquid refrigerant after it leaves the condenser, which may be done by passing the circulating water over the pipe leading from the condenser to the receiver. The receiver and the condenser together, however, hold the refrigerant in three conditions, the liquid, the gaseous, and the transition states, the latter being when it is being formed into the liquid from the gaseous state. The gas, it will be remembered, coming from the compressor, is hot. It passes in at the top of the condenser, where it meets the cooling water which has passed over the whole of the remainder of the coils of pipe forming the condenser, and from which it receives its first cooling.

The operation of condensing may be taken to consist of two parts—removing the heat of compression, and removing the latent heat of the gas. When the plant is working, at each stroke of the compressor a definite quantity of gas is sucked from the refrigerator coils, this being made up in the coils by a certain quantity of liquid, sufficient to expand into the quantity of gas removed by the compressor. If the compressor is double acting, at each stroke a certain quantity of gas is delivered to the condenser, and it may be taken that, when the apparatus is working normally, during the period of each stroke a certain quantity of gas is liquefied and added to the reservoir of liquid, equal to that which has been abstracted by way of the regulator valve, to make up for that which was taken from the refrigerator by the suction of the compressor.

If the condenser and receiver together are short of liquid, the working of the system is upset, because the liquid is abstracted by the suction of the compressor faster than it is replaced by the action of the condenser. The effect is not apparent immediately. In all these matters in connection with refrigerating plants, time is an important factor, but after a certain time the liquid in the condenser ceases to act as a barrier or absorber to the gas coming over from the compressor, and at each suction stroke of the compressor, a portion of the gas passes through the regulator valve, with a certain quantity of liquid. As was explained before, this leads to an immediate fall in the efficiency of the apparatus, and in the work done by the plant in cooling the cold store, or whatever the arrangement may be, because, while the liquid passing into the gaseous condition extracts a definite number of heat units for every pound of liquid evaporated, the gas which comes over has practically no refrigerating effect at all, and it lowers the refrigerating effect of the liquid which it accompanies.

The fact that the system is short of liquid, and that the gas is coming over with the liquid to the expansion coils, may be known for certain by placing the ear in the neighborhood of the regulator valve. When liquid only passes the regulator valve, it makes a hissing sound, to which the engineer soon becomes accustomed, and which he readily recognizes. When gas comes with the liquid, the hissing sound is accompanied by a rattling which is also unmistakable. When the system is short of refrigerant it will easily be understood that, as a portion of the space in the evaporating coils is occupied by the gas which comes over from the condenser in place of liquid, so also the cooling effect upon the suction pipe and upon the compressor itself, which depends upon the evaporation of the liquid, is also lessened, with the result that the frost is lost from the suction side of the compressor. In addition the compressor itself often becomes very hot, this leading to other troubles, such as the destruction of the packing, leading again to leakage of the refrigerant, to the vaporizing of the lubricant, and its being carried over with the gas, as vapor into the condenser, this giving troubles that will be explained later on.

The remedy is to add liquid to the system in the same manner as when charging, adding carefully until the signs disappear. When a shortage arises, however, it will always be wise to find out the cause. Leakage, as before explained, is one of the possible causes. Another cause is the possibility that oil has got into the system, as explained above; a third that air has got in; a fourth that the cooling water is not sufficient, that the condenser is not doing its work properly; and a fifth, which is easily looked out for and provided for when the ship passes into warmer climates, that the hotter cooling water is not doing its work as well as the colder water of a temperate climate. A little consideration will show when the cooling water from any cause is insufficient. If on passing into the tropics the water available is hotter, while the circulating pumps will not allow of a larger quantity being passed through the condenser in the proper proportion, less liquid refrigerant will be formed during the period of each stroke, and the reservoir of liquid will become less, with the result that after a certain time the results of shortage mentioned above will be apparent. The remedy is to add liquid refrigerant, as described above.

Anything which interferes with the process of the condensation of the gas will also interfere with the working of the system, and will produce the same results as a shortage of the refrigerant. They will lead, in fact, to a shortage in the system, because, just as explained with higher temperature cooling water, and with a limited quantity of cooling water, a smaller quantity of the gas will be converted into liquid in a given time, say within the duration of a stroke of the compressor. Among possible causes of interference with the process of condensation are,—higher temperature of cooling water, as already explained; shortage of quantity of cooling water; inefficient working of the cooling water circulating pump; and any deposit which forms on the outside of the condenser pipes. Sea water, and

most cooling waters, contain salts in solution, some of which are deposited upon the metal surfaces over which they run, such as the condenser pipes, especially when the pipes are hot, as they must necessarily be in a condenser; and the deposit is increased whenever the velocity of the cooling water is decreased.

The best conditions under all circumstances for taking the heat out of gas or out of steam by the aid of circulating water, in a surface condenser, are, that the water shall pass very rapidly over the surfaces of the pipes, on the other side of which the gas or steam is passing, and that the thickness of the pipes shall be as small as is consistent with mechanical strength, and with the necessary ability to withstand the strains brought by expansion and contraction, under changes of temperature. A deposit is formed from the cooling water, as marine engineers know to their cost. They have it in another form in boilers in which sea water is employed for raising steam. It has a high thermal resistance, as refrigeration engineers express it.

The deposit of salts or scale opposes the passage through itself of the heat, and therefore lessens the quantity of heat taken by the cooling water in a given time from the gas or steam that is to be cooled. The result is that, with a given quantity of cooling water passing, say with a given capacity of circulating pump, a smaller quantity only of liquid refrigerant is produced, and the other signs of shortage in the system are in evidence. On the other hand, anything which tends to increase the effective working of the condenser, such as the presence of a lower temperature of cooling water, instantly tends to lower the condenser pressure, because a larger quantity of liquid refrigerant is produced, a larger quantity will be passing through the regulator valve, unless it is closed a little more than previously, and there will be signs similar to those where there is too much refrigerant present in the system. It need hardly be mentioned that the lower the pressure in the condenser, the less the work the compressor has to perform, and the less the work the cooling water has to perform.

Hence, the "freezer" engineer will watch the temperatures of the delivery pipe, the suction pipe, and the compressor itself. If he finds his condenser pressure going up, and especially if it is accompanied, as it usually will be, by increased heat of the delivery pipe, it may be that the refrigerant is not passing through the regulator to the evaporator as quickly as it should; and, again, this may be caused by a greater demand upon the cooling water in the evaporator coils, owing to other causes in the cold chamber which will be dealt with further on.

Another Turbine Steamer.

The ever-increasing fleet of turbine steamers has just been augmented from the yard of John Brown and Company, Limited, Clydebank, Glasgow, who have launched the turbine steamer *St. David,* the first of the two vessels for which they contracted for the new Irish Channel service of the Fishguard and Rosslare Railways and Harbor Company, Ireland. With these steamers the journey between London and the tourist resorts in the south of Ireland will be reduced by several hours. The turbine type of engine has now been proved to be the most efficient for high speed traffic, and the most comfortable for the passengers, as it reduces vibration to a minimum. These new steamers will be unequaled for speed on any cross channel service in the United Kingdom, as they will maintain a speed on service of 22½ knots.

The *St. David* is of the following dimensions:—length between perpendiculars, 350 feet, breadth molded 41 feet, depth molded 17 feet 8 inches. She is constructed throughout of mild steel to Lloyd's highest classification for channel service. The passenger accommodation is equal to any in the most modern of Atlantic liners. On the lower and main decks, amidships and forward, sleeping accommodation is provided for 200 first-class passengers. The majority of the staterooms are of the tandem type. In addition to the ordinary first-class state-rooms, there are several special state-rooms at the after end of the deckhouse on the promenade deck, fitted up in a most luxurious manner. On the lower and main decks, aft of the after cargo space, sleeping accommodation is provided for a large number of second-class passengers. The first-class dining saloon is on the main deck forward, and occupies the full width of the ship. Above the dining saloon is the drawing-room, decorated in the "Adams" style, while aft of the drawing room and grand entrance is a comfortable, airy smoking room. The ventilation of the vessel has been specially considered, and having to secure an ample air supply to all compartments, the thermotank system has been adopted.

The *St. David* has been designed with large holds, and is supplied with the latest appliances for the rapid handling of goods. She has also an insulated hold and a complete installation of electric light.

The propelling machinery consists of three Parsons turbines, each driving a separate shaft and propeller. Steam is supplied by eight large single-ended boilers, fitted with Howden's forced draft. The whole of the machinery has been designed and constructed by the builders of the ship. B. T.

The London Thames Steamers.

Considerable dissatisfaction has been manifested in London concerning the operation of the thirty steamers owned by the London County Council, and described at page 214 of our issue for May, 1905, and at page 233 of our issue for June, 1906. Until 1904, steamers on the Thames were operated by a private company. They were slow wooden boats and were generally believed to have been operated at a loss, mainly because the service was totally inadequate. They were considered a disgrace to London, but the company declined to put on new boats or increase the service, whereupon the County Council took over the line and built the new boats. It was expected that the line would not immediately pay expenses, and a probable deficit of $30,000 or $35,000 a year was looked upon with equanimity.

Two services were put on by means of these steamers, one being a local service stopping at a large number of piers, while the other was an express service, making few stops along a distance of ten or twelve miles. Small and inadequate as the new steamers are, they were, of course, a great improvement upon the old ones, and for a short time they were well patronized. In cold weather, however, the patronage fell off very markedly, because the steamers have no deck houses, the only shelter above decks being provided by flimsy awnings. In rainy weather, passengers on these steamers could get in out of the dampness only by going into the little cabin, the floor of which is below the waterline, and which is dark and unventilated. In spite, however, of the great falling off in patronage during the winter, the County Council ran the boats with almost the same frequency as during the summer. The result was that the deficit during the first year amounted to $250,000, in place of the $30,000 which had been expected. Estimates for the next year indicate a similar deficit, and, owing to the extension on both sides of the river of electric lines, it has seemed probable that this deficit might ultimately become much greater. As a result of the great expense of keeping up a service which is not well patronized, it has been decided to lay off these boats during the winter season, beginning with October 1. Up to the date just mentioned the total cost of the enterprise, including the buying up of the line, the cost of the boats and the deficit, has figured out more than $1,200,000.

Keel plates were laid December 3 in the dockyard at Portsmouth for a new battleship which, it is announced, will be larger and more powerful than the *Dreadnought.* Much of the preliminary work having already been done, as in the case of the former ship, it is expected that the construction will progress rapidly.

FOURTEENTH ANNUAL MEETING OF THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.

The fourteenth annual convention of this society took place in New York on Thursday and Friday, November 22 and 23, 1906. The first session was called to order by the president, Rear Admiral Francis T. Bowles, president of the Fore River Shipbuilding Company.

The secretary-treasurer in his report on the condition of the society at the close of the fiscal year ending October 31, 1906, showed a total membership of 857, as compared with 862 a year ago. From the financial point of view the society is in a very good condition, the total receipts during the year having amounted to $10,396, which, added to $1,009 on hand at the beginning of the year, showed a total available of $11,405. Expenditures connected with the publication of Volume XIII of the *Proceedings,* and miscellaneous printing, amounted to $6,861, and other expenditures brought the total up to $10,131, leaving a balance to the credit of the society of $1,274. The statement of resources and liabilities showed total resources, after deducting doubtful accounts, amounting to $24,895. As the liabilities are nil, these resources represent the net assets of the society at the present date. The increase over last year is $405.

The following elections of new members took place:

Life Associate, 1.—Cornelius Vanderbilt, 30 Pine street, New York.

Members, 20.—Frederick Wallace Baker; Charles E. Burney; Halwell Selden Colby; Wm. T. Donnelly, consulting mechanical engineer, 780 East 18th street, Flatbush, Brooklyn; R. T. Hall, commander, U. S. Navy, Navy Department, Washington, D. C.; Georges Hart, chief engineer, 99 Rue La Fayette, Paris; John J. Herrick, mechanical engineer, Department of Docks and Ferries, 27 Madison avenue, Tompkinsville, S. I.; Andrew Laing, director and general manager, The Wallsend Slipway and Engineering Co., Wallsend-on-Tyne, England; Simon Lake, Bridgeport, Conn.; Robert McGregor, superintending engineeer, Metropolitan Steamship Co., India Wharf, Boston, Mass., 55 Vernon street, Brookline, Mass.; William T. Nevins, superintendent of construction, Sherman Co., Chicago; Frederick S. Nock, naval architect, East Greenwich, R. I.; Antonio C. Pessano, president Great Lakes Engineering Works, Detroit, Mich.; O. C. Roeder, consulting engineer, 38 Klauprecht street, Karlsruhe, Germany; Joseph A. Scott, naval architect, 95 Liberty street, New York; Charles Skentelbery, consulting engineer, Jacobs, Davies and Barringer, 95 Milk street, Boston; A. C. Smith, general superintendent, Chicago Shipway Co.; Dwight True, chief hull draftsman, Great Lakes Engineering Works, Detroit, Mich.; William E. Waterhouse, naval architect and engineer, 15 Whitehall street, New York; Llewellyn Williams, superintendent of refrigeration, United Fruit Co., 131 State street, Boston.

Promotion to Member, 1.—L. H. Chandler, lieutenant commander, U. S. Navy Department, Washington, D. C.

Associates, 14.—Edward B. Barry, captain U. S. N., care of postmaster, New York; R. D. Bucknam, captain, U. S. embassy, Constantinople, Turkey; Arthur T. Chester, The Aeolian Co., 362 Fifth avenue, New York; Maxwell W. Day, assistant engineer, power and mining department, General Electric Co., Schenectady, N. Y.; W. A. Engeman, president, Benvenue Granite Co., 41 Park Row, New York; W. B. Fogarty, assistant naval constructor, U. S. N., Navy Yard, Portsmouth, N. H.; Adrian Gips, general agent, Holland-America Line, 39 Broadway, New York; Richard Henderson, captain, U. S. N., Salisbury, N. C.; William F. Piek, Jr., Holland-America Line, Rotterdam, Holland; H. Raouf, I. O. N., British P. O., Constantinople, Turkey; Walter H. Singer, general manager, Singer Dock Co., Duluth, Minn.; J. A. Spillman, assistant naval constructor, U. S. N., Navy Yard, Norfolk, Va.; Henry R. Sutphen, vice-president and general manager, Electric Launch Co., Bayonne, N. J.; S. B. Thomas, lieutenant, U. S. N., Torpedo Station, Newport, R. I.

Juniors, 6.—Joseph Barraja-Frauenfelder, Quincy, Mass.; Daniel M. Callis, estimator, scientific department, Maryland Steel Co., Sparrow's Point, Md.; Francis J. French, ship draftsman, construction and repair department, New Orleans, La.; Dwight S. Simpson; William L. Wallace, Jr., fellow in naval architecture, Cornell University, Ithaca, N. Y.; Daniel I. Whittelsey, superintendent, Williams-Whittelsey Co., Steinway, Long Island City.

In a resolution unanimously adopted by the society, and presented by a committee, of which Mr. Charles H. Haswell was chairman, thanks were extended to the Honorable Secretary of State for his advocacy of some measure of relief to the merchant shipping of the United States engaged in the foreign trade. The president of the society was re-elected for a term of three years, after which, in accordance with provisions of an amendment to the constitution adopted last year, he will be ineligible to immedate re-election. Two members of council, W. D. Forbes and D. W. Taylor, were also re-elected to succeed themselves. On the evening of Friday, November 23, the annual banquet took place at Delmonico's, the society being addressed by Secretary of the Navy Charles J. Bonaparte, Rear Admirals Joseph B. Coghlan and Francis T. Bowles, Messrs. John Craig, Walter M. McFarland, and others.

THE PRESIDENT'S ADDRESS.

The affairs of your society are set forth in the report of the secretary-treasurer, adopted by the Council, and while generally in satisfactory condition, the society's membership, exclusive of the 37 elected this morning, standing at 857, shows a slight reduction for the year. The financial condition of the society is satisfactory, and shows a slight improvement during the year, the society's total resources amounting to $24,895. A matter calling for remark is the large amount owing for delinquent dues, amounting to $6,054. This is evidence of a continued depression in the shipbuilding industry, and it has been the policy of the society's management to deal leniently with it, anticipating or trusting that the majority of its delinquent members will desire and do desire to continue their membership.

While the government's record of commercial shipbuilding for the past fiscal year indicates a pitifully small showing of steel construction on the seaboard, it is a gratification to the Chair to be able to indicate a great improvement for the coming year, and evidences of a more satisfactory showing for shipbuilding generally than has ever taken place in the life of this society. During the fiscal year ending June 30, 1906, the United States built and documented 1,221 vessels, including canal boats and barges, of 418,745 gross tons, compared with 1,102 vessels of 330,316 gross tons for the previous year. The steel steam tonnage was 118,790 gross tons greater than during the previous fiscal year, and all other forms of construction together show a decrease. On the seaboard, only three steamers, of 15,344 tons, were built, and ten vessels, of 16,681 tons, for river and bay service. On the Great Lakes the majority of the tonnage was built, consisting almost wholly of large steam cargo vessels, forty in number, and amounting to 232,366 tons. During the current fiscal year, vessels have been begun on the lakes indicating even greater activity than for last year; and orders have been given for vessels on the seaboard for the coast trade indicating a considerable demand for steel steam tonnage for that service. It is probable that the output of merchant vessels, almost wholly in steam vessels, for the year 1907, will exceed the greatest amount ever built for one year in the United States, namely: 1855, when 583,450 tons were constructed.

On July 1, 1906, 78 merchant vessels, of 159,000 tons, were under construction on the coast, against 49, of 86,000, the year preceding. Of these 78 vessels, only two will engage in foreign trade, and these are to take the place of two steamships bought by the government for its line to the isthmus of Panama. On

the lakes, 40 vessels of 223,000 tons were under construction on July 1, against 27 vessels of 104,000 tons a year ago.

It is gratifying to be able to predict, confidently, that we in the United States shall not be much longer subject to the reproach that our tonnage in the foreign trade is less now than it was one hundred years ago. The bill prepared by the Merchant Marine Commission for the development of foreign commerce under the American flag, passed the Senate of the United States at the last session of Congress, and is now before the Committee on Commerce of the House of Representatives, at whose hearings during the last session much favorable comment was developed from widely diversified interests throughout the United States.

Elihu Root, that distinguished citizen of New York, now Secretary of State, has recently returned from a trip around South America, and after making a careful study of our commercial relations, has become convinced of the methods which should be followed in developing our commerce with that great country. He has expressed his judgment upon the bill of the Merchant Marine Commission in no uncertain terms, and I quote with pleasure from his address before the Trans-Mississippi Commercial Congress in Kansas City, on November 20. After reciting the now unquestioned fact of the subsidies paid by other maritime nations to their steamship lines, he says:

"It is estimated that about $28,000,000 a year is paid by our commercial competitors to their steamship lines. Against these advantages to his competitor the American shipowner has to contend; and it is manifest that the subsidized ship can afford to carry freight at cost for a long enough period to drive him out of business. We are living in a world not of natural competition, but of subsidized competition. State aid to steamship lines is as much a part of the commercial system of our day as state employment of consuls to promote business.

"It will be observed that both of these disadvantages under which the American shipowner labors are artificial; they are created by governmental action; one by our own government in raising the standard of wages and living, by the protective tariff, the other by foreign governments in paying subsidies to their ships for the promotion of their own trade. For the American shipowner it is not a contest of intelligence, skill, industry and thrift against similar qualities in his competitors; it is a contest against his competitors and his competitors' governments, and his own government also.

"Plainly these disadvantages created by governmental action can be neutralized only by governmental action, and should be neutralized by such action."

He then discusses the remedies proposed, and after a careful discussion of the suggestion of free ships and discriminative duties, which he rejects, the former as an inexpedient one which would merely sacrifice the American shipbuilding industry and the latter as one which cannot be seriously considered from its interference with existing commercial treaties and relations, he says:

"There remains the third and obvious method—to neutralize the artificial disadvantages imposed upon American shipping through the action of our own government and foreign governments by an equivalent advantage in the form of a subsidy or subvention. In my opinion, this is what should be done; it is the sensible and fair thing to do. It is what must be done if we would have a revival of our shipping and the desired development of our foreign trade. We cannot repeal the protective tariff; no political party dreams of repealing it; we do not wish to lower the standard of American living or American wages. We should give back to the shipowner what we take away from him for the purpose of maintaining that standard; and unless we do give it back we shall continue to go without ships. How can the expenditure of public money for the improvement of rivers and harbors to promote trade be justified upon any grounds which do not also sustain this proposal? Would any one reverse the policy that granted aid to the Pacific railroads, the pioneers of our enormous internal commerce, the agencies that built up the great traffic which has enabled half a dozen other roads to be built in later years without assistance?

"Such subventions would not be gifts. They would be at once compensation for injuries inflicted upon American shipping by American laws, and the consideration for benefits received by the whole American people—not the shippers or shipbuilders or the sailors alone, but by every manufacturer, every miner, every farmer, every merchant whose prosperity depends upon a market for his products.

"The provision for such just compensation should be carefully shaped and directed so that it will go to individual advantage only so far as the individual is enabled by it to earn a reasonable profit in building up the business of the country."

During the past year, American shipbuilders have undertaken the introduction of the coming motive power—turbine machinery. The first vessel for coast service equipped with turbine engines, which has recently made her successful trial, was under the construction of one of the ablest and most popular members of this society. The Navy Department has contracted for two scout vessels with turbine engines, and is apparently about to introduce turbine engines in battleships. Other turbine vessels for coast service have been contracted for and will be delivered at an early date.

American shipbuilders have reason to be proud of the naval vessels completed during the past year. The number of first class vessels, battleships and armored cruisers, completed and accepted during the past year has been exceptionally large, but the amount of new tonnage begun or authorized shows a great falling off. It is anticipated by members of our society that the developments in marine engineering during the past year will exercise a marked effect on new naval construction.

PAPERS AT FIRST SESSION.

THURSDAY MORNING.

A FIRE-PROOF FERRY-BOAT.

BY F. L. DUBOSQUE.

This paper will be found published in full at page 18.

PAPERS I AND II WERE DISCUSSED TOGETHER.

CONSTRUCTION OF A FIRE-PROOF EXCURSION STEAMER.

BY WILLIAM GATEWOOD.

ABSTRACT.

This is a description of the steamboat *Jamestown,* which was illustrated and described at page 421 in our November number.

The term "fire-proof" as applied to such a vessel means not that it is incapable of destruction by fire, but that the amount of combustible material built into the vessel has been limited to such an extent, and what is used is so protected and distributed, that the chances of a fire starting on board are greatly reduced, and the spread of fire, should one get a start, would be practically impossible.

In the design, no trouble was experienced in this connection below the main deck, as the hull was constructed of steel throughout. Above the main deck, however, considerable trouble was experienced in settling upon the design. It was at first considered practical to build the saloon and shade decks of light steel riveted to steel beams, but after several experimental sections had been built, it was decided that exposure to the sun and weather and the difficulties attending upon buckling due to the riveting of thin material, would require a thickness of plating no less than three-sixteenths inch. The weight of such plating would have reduced stability to an inadmissible degree. The result was that pine decking was laid upon steel angle beams, the under surface of the decking being covered with thin sheet steel rolled with shallow corrugations.

The usual canvas covering for the decks was not considered satisfactory on account of danger from cigar stubs; but

asbestos tiling was found unsuitable because of lack of toughness. The final covering consisted of canvas to secure water tightness, and on this interlocking rubber tiling. It is thus seen that most of the wood that is used is covered with non-inflammable material.

DISCUSSION.

Frank B. King.—Linoleum is a fire resistant up to a certain point, but after that it appears to be a distinct promoter of fire. The same may be said of rubber tiling, which is usually quite resinous, and when once ignited will burn rapidly. Both of these substances are rather difficult to ignite, but both are dangerous when a fire is already under way. With regard to wood framings and other fittings which are ordinarily made of wood, and which in the ferryboat described have been covered with sheet copper pressed on by special machinery, it would be a tremendous advantage if some means could be found whereby copper could be deposited upon these framings by some process analagous to galvanic action.

With regard to corrugated steel partitions; any motion of the vessel would be liable to cause these to make considerable noise. They may, however, be made of extreme stiffness by the simple expedient of fitting a double thickness, the corrugations in the one thickness running at right angles to those in the other. Another suggestion that might be made, and which would result in the production of an extremely stiff partition, would be to follow the idea carried out in photographic mailing board, where corrugations are placed between two plane surfaces. To prevent partitions of this character from sweating, they are frequently covered with cork paint. It might be suggested that a muslin covering thoroughly painted would give results fully equal to the cork, and at probably less expense and weight.

Stephenson Taylor.—The Fall River Line steamer *Bristol,* which was burned in 1888, was the immediate predecessor of the *Plymouth,* which was burned last March. In fact, the existence of the *Plymouth* was due to the burning of the *Bristol,* which necessitated the building of a new steamer. Both of these steamers burned at a time when they were almost empty of people. The unceasing vigilance displayed by the Fall River Line officers and employees while the boats are in actual service has so far prevented the occurrence of any such catastrophe when passengers were aboard.

The problem of rendering a boat of this character fireproof is one of infinitely greater complexity than is the case with a ferryboat, particularly when the latter, as in the one described, has only a single deck above the main hull. Passengers on vessels like the sound steamers require invariably that their rooms shall be up in the air. They will not accept rooms in the hull, as is the position of so many of the staterooms on Atlantic liners. The result is, there is a tremendous structure above the main deck, and any attempt to fit fireproofing of the character demanded by present requirements would involve a great amount of expense, and would result in placing excessive weights at such a height as to render doubtful the provision of a proper stability for the vessel. Of course, in the case of the ferryboat, a very large proportion of the side is made up of the glass windows, and this glass would have the same weight, whether the fittings are fireproof or not. Such conditions do not obtain in like measure on a sound steamer, hence it is not possible to make the same relative saving in weight.

The provision of steel bulkheads or partitions gives a structure which is extremely noisy in a seaway, and it is very hot in hot weather and cold in cold weather. It is a condition of affairs which passengers will not accept, and we must, therefore, look to some other means of providing for their safety. On a man-of-war, where such partitions are fitted, the occupants have to remain there whether they wish or not, but the same is not true in a passenger boat. The *Plymouth* was fitted with a sprinkler system designed to operate whenever the heat in any compartment caused a fusible plug to blow out. Some passengers might object to a sudden and unpremeditated shower bath in the middle of the night.

G. W. Dickie.—It seems to me that where corrugated iron is fitted in this way there will be liable to be found corrosion back of it. With regard to the form of boilers used, the author of the paper seems to prefer the watertube as being less dangerous. The Scotch boiler has a good record so far as explosions are concerned. It seems to me that the watertube boiler would be the more apt to cause a fire, inasmuch as the furnace is in most types outside the main structure of the boiler.

Spencer Miller.—It seems to me that the problem of rendering fireproof, or nearly so, a vessel of the ferryboat or sound steamer character need not necessarily involve making her so proof against fire as to render it impossible for her to be consumed. If the fire could be held in check, or retarded, for a period of half an hour, that would appear to be all the requirement necessary in the case; for these vessels operate so close to shore that relays of their lifeboats could take care of passengers and crew within that space of time. This is, of course, on the assumption that such vessels carry boats in wholly insufficient quantity to take care of the entire complement at one loading.

William Gatewood.—Regarding the inflammability of rubber tiling; one of the Lackawanna ferryboats caught fire some months ago, and it was generally understood at the time that the rubber tiling on the decks, by retarding the progress of the fire until it could be properly fought, was what saved the boat from destruction. This tiling has been found unsatisfactory on the *Jamestown* for various reasons, it having shown a disposition to work loose, and to retain water under it. No proper substitute has yet been found, and it is probable that the deck will be covered with canvas heavily painted. This is merely a makeshift device.

F. L. Du Bosque.—As to the increased expense of building the *Hammonton* in a fireproof manner as compared with the usual construction, I will say that the 7 percent mentioned in the paper was a percentage on the total cost of the vessel, and not on the joiner work alone. The latter cost probably double what the ordinary construction would have cost. The composition of asbestos and cement used in the partitions has proved itself very highly fire resistant, as may be realized from the fact that a powerful burner, capable of sending a heavy flame to a distance of six feet, was directed against a sample at a distance of one foot, and played at full force for six hours. The result was that the sample was badly blackened, but sustained no evidence whatever of any disintegration. Below the main deck the watertight bulkheads are fitted with United States navy standard watertight doors. The metal seats are so similar in appearance and general feeling to wood that the average passenger will not appreciate the difference. They are not hard or uncomfortable, as might be expected from a mere statement of the material used.

PERFORMANCE OF THE PADDLE-WHEEL STEAMBOAT NEW YORK, OF THE HUDSON RIVER DAY LINE.

BY PROFESSOR JAMES E. DENTON.

This paper will be found published in full at page 23.

DISCUSSION.

Stephenson Taylor.—It might be mentioned that the steamer *New York,* as she now exists, is 30 feet longer than was the case with the original vessel. As first built, the steamer had a length of 300 feet, and a draft of 5 feet 10 inches. The displacement was about 1,000 tons, as compared with 1,240 tons, and the block coefficient was 0.50, as compared with 0.548 at present. The paddle-wheels were also larger, having an outside diameter of 30 feet 2 inches, with paddles 3 feet 9 inches wide and a dip into the water of 4 feet 2 inches when the vessel was stationary, and 4 feet 6 inches when running. The lengthening of the vessel took place between the boilers and the paddle-wheels, which accounts in some measure for the position of the latter.

A trial trip, run May 23, 1888, over a course of one mile, showed as the mean of two runs in opposite directions an average of 22.8 miles per hour, with 32¾ revolutions per minute. This was attained by the development of much more power than was shown in the present test. The average of three runs over this course gave a speed of 22.5 miles per hour.

It might be remarked that the results shown on the present trial gave an exceedingly good figure for the horsepower developed per square foot of grate, with simple engines.

PAPERS AT SECOND SESSION.

THURSDAY AFTERNOON.

PERSONAL IMPRESSIONS OF SHIP-MODEL TOWING STATIONS.

BY PROFESSOR C. H. PEABODY.

This paper will be found published in full at page 25.

PAPERS IV AND V WERE DISCUSSED TOGETHER.

THE EXPERIMENTAL TANK AT THE UNIVERSITY OF MICHIGAN.

BY PROFESSOR HERBERT C. SADLER, SC. D.

ABSTRACT.

This is a brief description of the experimental model tank included in the basement of one wing of the new engineering building at Ann Arbor. The tank is 300 feet long, 22 feet wide and has a depth of water of 10 feet. The construction is of concrete throughout, the sides forming the foundation walls of the building. The bottom is arched, and reinforced with expanded metal. Along each side is a concrete bracket for carrying the rails for the dynamometer truck. At the south end is a dry-dock, with filters through which the tank is filled. A gallery extends along each side. A model preparation room is situated at the south end, and machinery has been installed for the preparation of models measuring from 10 to 14 feet in length.

The dynamometer truck consists of beams and channels carrying a driving motor, and a motor-generator set for supplying power. The truck is capable of being driven at speeds varying from 15 to 800 feet per minute, speed regulation being obtained from a controller. A towing dynamometer is connected by suitable mechanism with a recording drum, giving an autographic result of each experiment, somewhat after the manner of an ordinary indicator card. The instrument is carefully calibrated, in order to obtain means for reading the results.

DISCUSSION.

D. W. Taylor.—The use of paraffin for models is inadmissible in Washington on account of the high temperature experienced through most of the summer. For this reason wood is used by us exclusively. Above seventy-five degrees Fahrenheit paraffin may be said to be a sort of liquid or semi-fluid, because of the fact that it changes its shape; although, on account of its extreme viscosity, this change is very slow. It has come to my attention that in the new French Admiralty experimental tank much trouble has been experienced with paraffin models, because of the high summer temperatures in Paris. The last summer was a particularly warm one, and the difficulties were probably exaggerated, but it is certain that paraffin did not give results as definite as might have been desired.

We use in Washington models of about 20 feet in length, in preference to those of 12 feet used elsewhere, for two reasons. One is that the displacement is thereby made about five times as great as with the smaller models, and the application of the law of comparison is thus more closely to be relied upon. The other is that in the measurement of the forces involved there is less liability to serious error, because of the fact that accidental errors of observation are of much less relative importance. Even with the 20-foot model the resistance recorded is frequently below 10 pounds. This would mean less than two pounds for the 12-foot model, with consequent liability to greater relative discrepancies, due to small errors.

Tests of models with and without appendages give very different results with regard to resistance. Warships in particular have appendages of considerable size, resistance and complexity, including bilge and docking keels, propeller struts and bosses, etc. The resistance due to these appendages is usually about 10 percent of the total resistance of the vessel, and sometimes rises above 15 percent in particular cases. It is difficult to apply these appendages to paraffin models with sufficient exactness for our purpose, which fact furnishes another reason for making use of wooden models.

The subject of hollow lines as compared with straight or convex lines in the hull is one which is not thoroughly determined. At certain speeds and in smooth water there is a definite advantage due to the proper use of hollow lines. These speeds are about those represented in knots by the square root of the length of the vessel in feet. At such speeds, however, as are attained by vessels of the torpedo boat type, hollow lines present a distinct disadvantage. The lines here should be either straight or slightly full.

Professor Sadler's method of recording results of resistance tests in pounds per ton of displacement seems to me to be the best method yet devised, as it takes account of all the varying factors in the case, and gives results which may be applied directly for comparative or design purposes. With regard to the running of models at a predetermined draft, the capillary attraction of the water against the sides of the model would render the exact determination of draft a matter of some uncertainty. Not only this, but the actual shape of the model might not be known with sufficient exactness to enable the displacement to be figured very closely from these drafts as recorded. It is, therefore, advisable to carry out such experiments upon a basis of displacement of the model, instead of predetermined draft. It is quite easy to weigh the model, and if any changes are made in the weights aboard, proper account may be taken of these as the changes are made, and thus the actual displacement at any given moment may be accurately known.

Professor H. C. Sadler.—In our tank in the University of Michigan we have used paraffin for models, chiefly because of its cheapness. We have not all the money which might be desired for carrying on these experiments, and have to make the best use of what we have. We have little difficulty due to change of shape on account of high temperatures. We suspended ten-foot models in the water for several weeks, and measured the sag at the center, which we found to be only about one-eighth inch. After several weeks' further suspension no further sag was noticeable.

MODEL BASIN GLEANINGS.

BY D. W. TAYLOR, U. S. N.

ABSTRACT.

Propeller experiments at the naval model basin in Washington have been continued, a number of tests having been made covering such subjects as the rake of propeller blades, thickness of blades, form of blade sections, shape of blade, the suction or thrust deduction forward of a propeller, resulting from the reaction between the propeller and the ship, and the application of the law of comparison, so far as it relates to experiments upon propeller wheels. Fifteen propellers were tried under this latter heading, of diameters ranging from 8 to 24 inches, and arranged in five groups each of which contained propellers of 0.6, 1.0, and 1.5 pitch ratio.

The author makes the observation that there is very good theoretical basis for concluding that the law of comparison cannot apply exactly to propellers, it being based upon the assumption of precisely similar motions in the case of a model and the full sized screw. When applied to fluids, there must be no discontinuity of motion, with resultant eddying. As a matter of fact, however, there is discontinuity of motion in the operation of propellers, and eddying around the column of water acted upon within the screw disk. It appears reasonable to suppose that for

a fraction of the disk represented by 90 or 95 percent, the law of comparison applies with substantial accuracy, but that it fails for the remaining portion.

For propellers working in the open, the blade with a moderate rake aft has no appreciable superiority over the perpendicular blade; while the blade raked forward is slightly inferior to the others. The broad tipped blade, as might be expected, absorbs more power and delivers more thrust than the narrower one. As regards efficiency, the very narrow tips have distinctly the best of it, except for the fine pitch, and the elliptical blade appears to be slightly more efficient than the broader tipped blade. The fine pointed blades, however, are undoubtedly more liable to cavitation.

PAPERS VI AND VII WERE DISCUSSED TOGETHER.

A COMPARISON OF DURAND'S AND CURTIS AND HEWINS' PROPELLER EXPERIMENTS OF 1905.

BY EDWIN A. STEVENS.

This paper will be found published in full at page 27.

DISCUSSION.

Professor G. R. McDermott.—In order to make a proper comparison between experimental results of this character, they should be worked out or plotted on the same sort of basis. For example: the speaker has compared the results as published by Durand and Taylor with those of Froude and Rota, and found that whereas the two latter used the virtual slip, based on the development of zero thrust with zero slip, the two former used the conventional slip, and their curves show a decided positive thrust with no slip. It is simply a question of the longitudinal displacement on the curve of the positions of the various values of the slip.

H. M. McEntee.—A standard method of plotting results of experiments of this character would be a splendid thing to adopt, and it would seem that this society should formulate such a method, which might include the reduction of all results to a standard diameter of one foot and speed of advance of one knot. On this basis, efficiency should be plotted on thrust. It would, of course, be assumed that the thrust and other dynamical elements of the action of the propeller would vary as the square of the speed of advance, and also as the square of the diameter.

D. W. Taylor.—In connection with the comparisons between Professor Durand's results and those obtained under my supervision, it is only fair to remark that the blades of Professor Durand's propellers varied quite markedly from mine both in shape and contour, in width of blade and in thickness. Professor Durand varied the thickness directly with the width, while my propellers had a constant schedule of thickness for all widths of blade. The experiments shown on varying blade thicknesses serve to give indications that by applying a proper correction for the thickness of the blade his results and mine would be brought much closer together.

It may be said in general that cavitation depends upon the thrust of the propeller per square inch of projected area, and upon the acceleration of the water at the point in question, the one being dependent in large measure upon the other. The ill effects due to cavitation are obviated by increasing the width of the blade, and thereby reducing the amount of thrust developed per square inch of area. It seems to me, however, that although this result is experienced from increasing the width of the blade, the actual gain comes from the fact that this increase in width, with in general no increase in the thickness of the blade, is accomplished by a decrease in the angle of entrance, and hence in the disturbance caused by the blade in cutting the water.

PAPERS AT THIRD SESSION.

FRIDAY MORNING.

A MODERN FLEET.

BY CAPTAIN E. B. BARRY, U. S. N.

ABSTRACT.

The growing demands of armor, battery, engines, boilers and coal have reduced available stowage for other parts of the equipment of a war vessel, and, consequently, shortened the time which the vessel can keep the sea to such an extent as to require coal and provision depots near at hand in all naval operations. A ship's diminishing supplies can be replenished by going to the depot herself; by meeting cargo carriers in some convenient port; or by transferring on the open sea. The last is by all means the best except when weather and other unforeseen circumstances interfere. In outlining the developments of fighting ships drawings are given of the latest classes of battleships and armored cruisers, showing the gradual approach to simplification of battery, and reduction in armor thickness with gradual spread in the area which it covers. Great speed in battleships is being demanded, and there seems to be no way to supply the necessary weight except by additional displacement.

Homogeneity of size, speed, coal capacity, battery power and tactical maneuvering qualities are potent factors in an efficient fleet. It is only by the construction of types, and not of individual ships, and by the formation of homogeneous divisions of a nearly homogeneous fleet that a nation can develop a navy of such a character as to be of the highest possible use in time of war.

The modern battleship has the maximum available battery power on either beam, with bow and stern fire considerably less; bow fire frequently superior to stern fire. Her armor protects her vitals against all but the heaviest projectiles, and they can penetrate it only under favorable angles of impact. She is engined and boilered to attain the best speed possible, and carries as much coal as space will permit.

DISCUSSION.

W. J. Baxter.—The science of building up a fleet, whether naval or mercantile, is much advanced when captains and owners confer with designers and builders, giving facts and opinions relating to the operation of the several devices and fittings, and with recommendations as to what is needed, and what things, as fitted, are unnecessary. The twin sciences of naval architecture and marine engineering are much advanced when this collaboration takes place.

Professor William Hovgaard.—The monitor type of vessel need not be considered as obsolete. In the last analysis the *Dreadnought* is at present the highest development of the monitor. Even the smaller types of monitor are still useful under certain geographical conditions. It would seem that in waters like those of the Philippines this type could fill a very useful function for special purposes, and that it would be found profitable to build them for this service.

John F. Meigs.—In considering the armoring of a fleet, we know that with a definite weight of armament, composed of guns, mounts and ammunition, very different distributions of these weights may be made by different designers. With small guns, firing rapidly, a great volume of fire can be obtained per minute. With larger guns the volume of fire would be less, but the possible range of gun would be increased. If the gun is larger than is necessary for the penetration of such armor as is carried by the enemy at the range at which action takes place, a mistake has been made in fitting it. The gun should penetrate and no more.

G. W. Dickie.—In fitting out a fleet, the question of oil burning is one which is assuming gradually an increased importance. It seems to me that soon vessels will be fitted for burning oil, either alone or in conjunction with coal, and that this will particularly be the case upon our Pacific coast. A discussion like this might well include remarks upon the kind of motive power to be used in the future. Are we to see our new ships propelled by steam turbines, or by explosive engines? We are entering a new field, not only in steam engineering but in the development of the battery and defensive qualities of our vessels. It might be suggested that some armor be so fitted as to render nugatory the explosion of a torpedo against the side of the ship.

Rear Admiral F. T. Bowles.—The subject of simplification on

board ship is one which is deserving of the highest attention. The officer who argues in favor of simplifying the battery equipment might well consider the advisability of dispensing with an office which is never used, and with typewriters and other office equipment features for which is found only an occasional need. The saving that would thus be effected in weight could very properly be put into ammunition.

RECENT DEVELOPMENTS IN ARMOR AND ARMAMENT.

BY JOHN F. MEIGS.

ABSTRACT.

The tendency in the past few years has been to increase the area of the sides of ships covered by armor, and to increase the power of the guns. Armor has been improved materially by increasing the hardness of the exterior face and the toughness of the back, the latter quality resisting cracking and disintegration. Projectiles have been improved in the same manner. The contest between the efficiency of armor and that of projectiles has been going on continuously for half a century. The growth in the direction of using a large number of guns of a heavy caliber has been going on for fifteen years, being started by the *Oregon* class in the United States. The increase in the heavy caliber guns is laid to the introduction of a large number of circular or nearly circular turrets, in which the guns are usually mounted in pairs, although in some cases they are placed singly in the turrets. At the same time developments have taken place in the breech mechanism of heavy guns, permitting a great increase in the number of shots fired per minute, and training has done so much to improve the accuracy of the fire that results impossible five years ago are now of every day occurrence.

DISCUSSION.

Professor William Hovgaard.—In the development of the science of arming ships with heavy guns, the English navy carried sizes up to 110-ton guns fitted in the *Benbow, Victoria* and *Sans Pareil.* On account, however, of troubles experienced with these mammoth pieces of ordnance, due to the dropping of the chase and opening of cracks, and because of the very long time required to build such a gun, it being found necessary to delay the completion of a vessel until the gun could be finished, it was decided to abandon such heavy weapons. Another reason was that with the displacements then in vogue only two such guns could be carried on a single ship, and it was considered undesirable to make any decided increase in dimensions. Another point of undesirability was the very slow rate at which these guns could be fired, mainly because of the very heavy ammunition which was used.

The turret design shown in the paper reverts in certain measure to the old closed type of turret, but differs markedly in the shape of the hood. It seems to me that difficulty would be experienced by reason of the possibility that a shot might become wedged between the deck and the lower edge of the turret armor. In the new French design, the turret is so constructed that its armor overhangs the barbette in a sort of apron, and thereby prevents all possibility of any such difficulty. In the case of the barbettes shown, where the lower portion is of considerably smaller size than the upper, and of smaller diameter than the rolls upon which the turret turns, this seems to me a very unsafe construction, because of the fact that the foundation of the roller track is liable to damage by hostile shells.

Henry Capdevielle.—A disadvantage in decreasing the diameter of the barbette in the interest of saving weight, as has been done in the design presented, is that the roller path cannot be easily inspected, which seems to be a necessity in turrets and barbettes as now fitted. Another disadvantage of the design has to do with the very slight elevation of the top of the barbette above the main deck. This would permit water to get in easily, and flood the handling room and base of the barbette.

John F. Meigs.—The spiking of the turret by the introduction of a shell between the turret and barbette is, I think, unavoidable in the balanced type of turret, however this type may be fitted. In order that the turret may be balanced, the center of gravity of the turret must be over the center or axis of the barbette. In order that the port opening for the guns may be made as small as possible consistent with the proper action of the guns from the point of view of elevation, it is necessary to place the trunnions very close to the front plate of the turret, and the great weight involved at this point has necessitated the moving of the whole turret bodily to the rear, in order to balance the turret as above outlined.

The smaller barbette placed under the larger one is simply a suggestion in the way of saving in the weight of armor applied to the protection of the guns, mounts and ammunition communication. This saving is made at the expense of a certain degree of possibility of damage. It is merely a case of a balancing of evils, and choosing the lesser. In any event, this barbette at this point in the structure would be behind side armor of some thickness, certainly of enough thickness to burst any shells which might come there, and thus the element of danger mentioned would be markedly reduced. It is, of course, as stated above, simply a case of compromise between weight-saving and a slightly increased possibility of danger resulting therefrom.

With regard to water entering the barbette over the low top, this might easily be obviated by the provision of a sheet steel sheath or guard around the barbette, or fitted as a water shed across the deck of the vessel, such as is done in battleships and ocean steamships. This matter could easily be taken care of in some such manner.

NOTES ON THE DEVELOPMENT OF WARSHIP DESIGN.

BY R. H. M. ROBINSON, U. S. N.

ABSTRACT.

In naval designs the naval architect is not hampered by many of the regulations governing the operation, inspection and construction of merchant ships, or by the rules of registration societies as to scantlings and distribution of material in the hulls and appurtenances. It has been asserted that warships are too flimsily constructed, but their operation under various conditions of service have proved them structurally and locally sufficiently strong, in spite of the smaller percentage of weight allotted to the hull structures of warships than is the case in merchant ships. The same comment applies to the propelling machinery.

The criticism of any ship may justly be made only after a careful consideration of the state of knowledge on the subject at the time of her design. Often the high development of one feature in a warship has rendered inadvisable the continuation of another feature which was desirable in its original inception. As an example, the ram is now gradually disappearing on the high development of the gun. One of the most difficult problems is that of keeping pace with the rapid changes in naval opinion, based generally on experience, but sometimes on pure theory. The Spanish-American war demonstrated the necessity for the elimination of wood. The adoption of smokeless powder has made necessary a provision for low temperature in the magazines.

Improvements in ordnance coincident with improvements in armor have made the problem of protection difficult. The opinion that the large guns of a vessel should be of one caliber has facilitated concentration of fire, and permits a redistribution of ammunition when the supply of one or more of the guns runs low. The development of the steam turbine has contributed much to the solution of the speed problem, and it will contribute more in the future. The question of the necessity for extreme speed is one on which opinions vary widely. The problem of speed as now demanded would be impossible of solution but for improvements in the means of obtaining it. This includes the design of propellers as well as the question of the

propulsive engine. The development of submarine mines, submarine boats and torpedoes has rendered necessary a minute subdivision of the bottoms of ships in order to minimize the damage resulting from a danger which is very difficult to avert.

DISCUSSION.

Professor William Hovgaard.—It seems to me extremely unwise to abandon in big ships the use of intermediate caliber guns. There is a certain work for them to do, which they can do to much better advantage than can either the heavy turret guns or the smaller torpedo defense weapons, and as a considerable number of these guns can be carried on the same weight which would be required for a single gun of the heaviest type, it appears to me wise to continue fitting them in moderate numbers. The design of the *Michigan* shows that her eight guns can be trained through a total of twenty-four right angles, as compared with only twenty possible if four of the guns had been mounted upon the broadsides, in the manner usually adopted. To offset this great advantage in range of fire, we have a very high target, and the possibility that both turrets at one end of the ship might be put out of action simultaneously by a single high explosive shell.

It seems to me that in vessels of this character much might be gained in the way of weight saving, or of increase in speed, by using small tube boilers instead of the large tubes now so common on large ships. A further advantage would accrue from the fact that steam could be raised so much more quickly. Small tube boilers were fitted upon the Danish armorclad *Herluf Trolle,* and trials showed that it was possible to raise steam from cold water so quickly that within twenty-six minutes from the lighting of the fires the vessel was traveling at full speed. A further advantage might be derived from the use of the mixed combustion of oil and coal. The Navy Department seems to frown upon this idea, but it seems to me that it would be well worth a careful trial.

It has been suggested to place armor upon the bottom of the vessel, and it is understood that some of the Russian vessels have been so fitted. This seems to me an extremely unwise procedure, because of the fact that the enormous pressure generated by a high explosive fired under water, as is the case with submarine mines and torpedoes, would be such that no material whatever could resist it. If armor could be fitted along the sides of the vessel, but about 18 feet in from the side, it would take care of this proposition very nicely, and would be at a sufficient distance from the center of the explosive effort to resist successfully the effects of the explosion.

The action of the Russian ships at the battle of Tsushima in capsizing after being damaged by gunfire seems to point to the fact that the metacentric height given warships is not quite enough. As designed at present this height is usually about 3 feet. It seems to me that for vessels of 16,000 or 18,000 tons we ought to go to a height of 6 or 8 feet. To do this, all that would be necessary would be to increase the beam to a sufficient amount. This increase in the beam would probably be required by the fitting of the armor bulkheads as suggested above.

Spencer Miller.—The problem of coaling a war vessel is undergoing rapid development, particularly in the matter of coaling at sea. The Italian collier *Sterope,* which has a length of 380 feet and a carrying capacity of 6,000 tons of coal, is fitted with a Temperley cableway capable of carrying loads up to 1¼ tons. In a test with the cruiser *Liguria,* of 2,281 tons, when the sea was running so high that the propellers of the *Liguria* could be seen from the collier, a mean speed of 60 tons per hour was maintained. In some cases the loads carried were as high as a ton, and the period of time between loads was made as low as 35 seconds for the round trip, while no trip took more than 57 seconds.

John Reid.—It seems to me that the United States government, in limiting the size of battleships to 16,000 tons, is indulging in a conservatism which is extremely unwise. To get the requisite speed and battery power out of a battleship, higher displacements will have to be provided. All of your competitors in naval science are proceeding with the construction of vessels of much greater size than this, and unless the United States wishes to be left in the rear that same action will have to be taken here.

THE DEVELOPMENT OF SUBMARINES.

BY L. Y. SPEAR.

ABSTRACT.

France has led in the development of types of submarines, large numbers having been built for the French navy. During the last four years, however, Great Britain has practically overcome this lead, although the total number of boats is considerably less. The average efficiency, however, is so much higher as to make up for the deficiency in numbers. The development has been continuous, giving improvements in speed, radius of action, habitability and armament by successive increases in displacement. Thus it may be noted that the first set of five English vessels had a displacement of 122 tons and a cruising radius of 500 miles; the second set of four vessels were of 180 tons and 600 miles; the third set of eight vessels were of 204 tons and 650 miles; the fourth set of six vessels of 313 tons and 1,350 miles cruising radius.

The total number of submarines now in commission is said to be 104, while those authorized and building number 100 additional. The total of 204 is divided among France, 99; England, 48; Russia, 28; United States, 12; Italy, 9; Japan, 5; Sweden, 2; Holland, 1.

The demands for increased speed, armament and radius of action continue, the only possible answer being in increased dimensions and displacement. At present the ideal aimed at seems to be a surface speed of 15 knots, with a radius of action of two thousand miles, together with a submerged speed of from 9 to 10 knots. The principal difficulty of control when submerged lies in the fact that the depth gage records pressures rather than depths below the general level of the ocean surface, and hence in a wave formation makes it difficult to keep any accurate record of depth. In arriving at a conclusion as to the sufficiency of stability given by the submarine boat the form and construction must be taken into account; the form, so far as the forces tending to produce rolling are concerned, and the construction, so far as it affects the ability to roll heavily without danger of broaching. In both respects the submarine, particularly the type of circular section, is better off than the surface boat.

The following are universally regarded as the most important military qualities capable of exact definition: maximum speed light, and corresponding radius; maximum speed submerged, and corresponding radius; time to submerge from the light condition. The supplying of fresh air for breathing purposes is a simple matter, sufficient reserves of compressed air being carried to meet all possible conditions. In addition, chemical substances are now available for emergency use, which by the simple addition of water, will give off pure oxygen, while the residue will absorb carbon dioxide.

DISCUSSION.

W. D. Forbes.—In connection with the development of submarine boats, we hear a great deal about the successful results achieved by various vessels. Except, however, when a catastrophe occurs, in which life is lost, we hear very little about the failures or accidents. These are not made public. It seems to me that the scrap heap is one of the greatest educators which we possess, and that extremely illuminating results might be found from the submarine scrap heap.

Professor Wm. Hovgaard.—In submarines, gasoline engines seem to be preferred to petroleum engines, or, in general, to engines using the heavier oils. Gasoline as a fuel is extremely inflammable, and dangerous to store and use. The French, Germans and Russians seem to have been experimenting

with considerable success and satisfaction with the Diesel motor, which uses fuel of a heavier hydro-carbon type.

Simon Lake.—In 1893 there were submitted to the United States Navy Department designs of the first submarine of the "level keel" type, a type which depends for its submergence not upon a diving motion of the boat, but upon the action of a hydroplane which submerges the boat while keeping it on a level keel. At that time all the French boats, as well as the Holland vessels, were of the diving type, the bow being depressed for submergence. The Lake boats, as designed at that early date, had a heavy keel, which was releasable, if necessary; and they had a diving compartment, by means of which the crew could escape if the boat refused to rise. In the New York *Tribune* of October 22, 1894, appeared a full description of the *Argonaut II.* The *Narval* of the French Navy, which was designed after this, followed this same general plan. The hull is of double construction, and the submergence while the boat is under way is by means of the hydroplane.

The *Protector,* with which comparisons are made in the paper, was first fitted with a propeller of four blades, with a diameter of 45 inches, a pitch of 36 inches, and a projected area of blade of 56.3 percent of the disk. With this propeller, in November, 1903, the vessel steamed a distance of 3⅜ miles between lighthouses on Long Island Sound at the rate of 10.66 knots, and made upwards of 6 knots when fully submerged. The figures given in the paper were obtained with a much inferior propeller of three blades, 49 inches in diameter, 48 inches in pitch and with a projected area of 65 percent of the disk. With this propeller the speed was 1.5 knots less than with the other, although the power developed was greater by 30 horsepower. In spite of the inefficiency of this propeller, the vessel navigated with it under her own power from Bridgeport to Newport, and towed a schooner all the way. The propeller afterwards fitted was better than the second, but inferior to the first. It has three blades, a diameter of 61 inches, a pitch of 42 inches and a projected area of 33.5 percent. This was the propeller used by the Russian trial board after the vessel was sold to Russia. With this propeller a speed of 6.75 knots was obtained over a course of fifty miles, with the engine running at 248 revolutions per minute. A distance of 0.88 mile was run submerged in 9½ minutes, showing a speed of 5.6 knots, while various tests showed a cruising speed of 8.5 knots with 240 revolutions; 7.4 knots awash with 224 revolutions and from 5.4 to 6 knots submerged.

Tests of submergence showed that from the light condition to awash the change could be made in 11 minutes. To submerge the top of the conning tower an additional two or three minutes was required, while for a complete submergence and subsidence to a depth of 62 feet, a period of 58 seconds sufficed. It was found possible to change the operating power from engines to motors in 15 seconds. Stability is assured by the provision of a height of 22 inches between the center of buoyancy and the center of gravity. The United States Naval Board has listed in order the desirability of various qualities of the submarine boat. First of all, they place safety. After this come facility and certainty of operation when submerged, speed on the surface, speed submerged, endurance both on the surface and submerged, stability, visibility, etc.

L. Y. Spear.—The use of heavy oil in engines presents great difficulties in connection with the proper mixing for combustion. That is the reason why gasoline engines are used almost universally on submarines. The problem, however, is undergoing solution, not only in the United States but in England, France and Russia, as well. Up to the present date, however, no reliable method has come to hand for operating with the heavier hydro-carbon oils. The ventilation of the submarine presents a problem of little difficulty, the boats of the Holland type being so fitted that the air is changed in general every three or four minutes. This rapidity of change prevents the formation of an explosive mixture from a leakage of gasoline, and removes all source of danger from this character of fuel.

PAPERS AT FOURTH SESSION.

FRIDAY AFTERNOON.

THE EFFECT OF THE UNIVERSAL RULE IN RACING YACHTS.

BY MARTIN C. ERISMANN.

ABSTRACT.

The rules of the New York and Seawanhaka Yacht Clubs in 1882 were very similar, depending simply upon the length and the sail area. They were the parents of the scow forms and light displacement boats that brought racing to a standstill. With the advent of the *Gloriana,* designed by Herreshoff in 1892, the principle of the value of lengthening the sailing lines of the boats when heeled became apparent, and since then the overhanging ends of yachts have grown, until in some racing boats the deck length has been double that of the waterline. The sail area rules developed a type of boat which, on a light displacement and low center of gravity, would lengthen greatly when heeled. This development was apparent in the defenders of the *America's* cup, and was associated with great sail area, the use of very light materials in the structure, and of a considerable quantity of lead in the keel.

The first step in the direction of a midsection measurement was taken in England in 1896, the rule being modified in 1901. In an international conference in London, rules were adopted, to take effect January 1, 1907, which, it is believed, will produce vessels more fitted for all 'round work. The European rule thus adopted makes the rating one-half the sum of the length, the beam, the half girth, three times the "girth difference," one-third the square root of the sail area, and the freeboard taken negatively. The rule adopted in the United States gives the rating as the length multiplied by the square root of the sail area and divided by 5.5 times the cube root of the displacement. This is considered similar to the international rating rule. The rule now offers many variations in the selection of dimensions and factors, which will produce boats of considerable speed, but such as will be ships in every sense of the word.

EXPLOSIVE ENGINES FOR NAVAL PURPOSES.

BY ARTHUR T. CHESTER.

This paper will be published in full in our February number.

DISCUSSION.

R. C. Monteagle.—The statement that an efficient marine steam engine will burn from 2 to 2½ pounds of coal per indicated horsepower per hour is open to doubt. A marine steam engine to be considered very efficient would burn not over 1½ pounds, and, in the special case of such vessels as the *Inchdune* and sister ships, the consumption was brought down to not more than 1 pound. This class of ships had very extreme provision made for attaining great economy in coal consumption. There was a quadruple expansion engine with cylinders measuring 17, 24, 34 and two of 42 inches in diameter with a common stroke of 42 inches. Steam was used at the high pressure of 267 pounds per square inch, and was superheated to about 500 degrees Fahrenheit. An elaborate fuel economizer or feed water heater was fitted in the uptakes. It appears from the above that the statement to the effect that with the same amount of coal an explosive plant would carry the vessel two and one-half times as far as a steam plant should be modified to read one and one-half times, or even less, if it should be shown that the figures given for the explosive engine are too optimistic.

Regarding the weight of machinery per horsepower, which the author states to be 150 pounds in warship practice, it may be stated that in the latest torpedo boat practice the weight per horsepower, including all machinery and auxiliaries and the water in boilers, condensers, etc., has been brought as low as 60 pounds. The author states that the largest marine gas engine plant yet constructed is of about 300 horsepower, and from the weight per horsepower of this plant makes a general deduction regarding the weight of larger plants. It should be noted in this connection that the weight of a producer plant increases more rapidly than does the power developed by it. This is the case certainly in stationary plants, and I have no doubt that it

will apply equally well to those afloat. Besides this, the author seems to have confused the ordinary gasoline engine with producer gas plants, so far as the size of the largest plants under construction is concerned.

The argument that the producer plant will require less labor in the production of power, and particularly in the feeding of coal, is not entirely correct, because of the fact that in the steam engine the coal is thrown into the furnaces at a height convenient to the work of the fireman. With a producer plant this is not the case, as all the coal used has to be raised above the hoppers, which are ten or fifteen feet or more above the fire room floor. It would thus appear that the work required, although it may involve a handling of a smaller aggregate quantity of coal, is yet no less than in the case of a steam plant.

The argument that it is possible with such a plant to produce gas at an instant's notice, and thereby make use of the machinery without delay, is fallacious, because of the fact that a banked fire in the producer is accompanied by an extremely low temperature within the device, and the generation of no gas whatever. To raise this temperature to a sufficient point to generate gas requires a certain expenditure of time.

The argument against steam plants for torpedo boat work on account of the probability that sparks or even flame may issue from the funnels, is offset by the fact that the gas plant is an extremely noisy one to operate, and it would be almost as difficult to keep the enemy from discovering its whereabouts as in the present case.

M. M. Whittaker.—One of the greatest difficulties with producer plants is concerned with getting an even quality of the mixture. This makes considerable difficulty in the operation of the engine.

A. T. Chester.—The use of a double-ended cylinder, as suggested, involves certain complexity in the engine, but is of advantage because of the fact that while it doubles the number of explosions, and hence approximately the power generated, it does not by any means double the weight of the cylinder. With regard to comparative results between steam and producer gas plants as applied to marine propulsion, mention might be made of a test made in 1904, between a tug fitted with this type of generator and engine and a steam propelled tug of about the same size and power. The maximum pull recorded by a towing meter reached 2,190 pounds for the producer tug and 2,020 pounds for the other. On a ten hour's run at 8½ knots the producer tug consumed 530 pounds of anthracite, and the steam tug 1,820 pounds of steam coal. The cost of a given quantity of anthracite is greater than that of steam coal, but even allowing for this difference in cost the saving in the expense of operation is very marked.

TWO TIMBER DRY-DOCKS AND THEIR PUMPING PLANT.

BY F. P. PALEN AND G. L. SMITH.

This was a description of the two docks now in service at the yard of the Newport News Shipbuilding and Dry-Dock Company, Newport News, Va., and of the plant employed for pumping these two docks, either conjointly or independently.

The paper will be published in full in our February number.

A NEW SEA ANCHOR FOR COALING AT SEA.

BY SPENCER MILLER.

ABSTRACT.

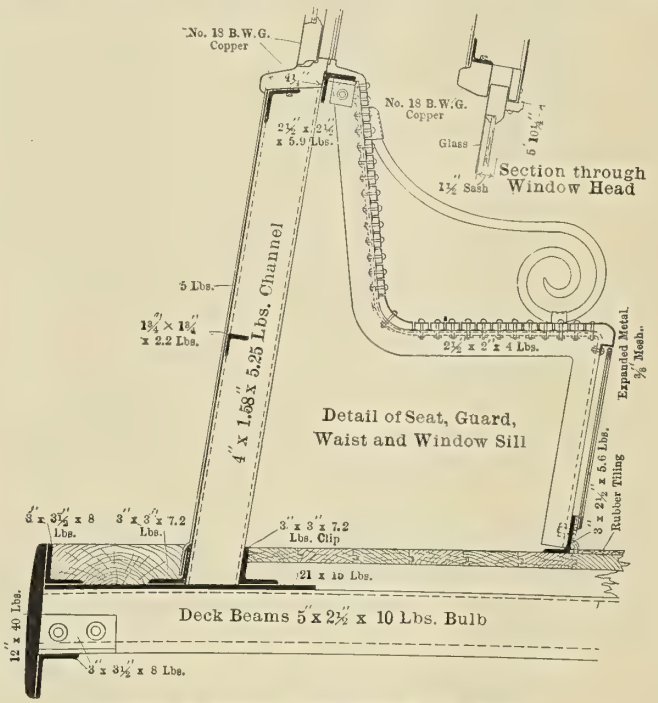
The sea anchor is required to maintain a practically uniform tension in the sea anchor line, thus permitting the collier, which is towed, to plunge or roll or otherwise alter the distance between the masts of the two ships. Tests of sea anchors have shown that with increasing speed the strains on conical anchors vary about as the square of the speed. With increasing diameters and constant speeds the strains vary about as the square of the diameter. The flexible bale is preferred to a stiff bale because of the fact that the latter is liable to become bent in operation. The flexible bale, however, can take care of a strain only about five-sixths of that taken by the stiff one.

A multiplane sea anchor has been developed which on test has shown that with the same amount of canvas it will pull as much as the conical anchor of diameter equal to length. With five planes, this anchor will pull perfectly straight, without diving, broaching or yawing. Swivels are required to keep the sea anchor line from becoming fouled with the tripping line. With the multiplane anchor the strains do not increase according to the law of squares, but more slowly as speed is increased. Comparing the multiplane anchor with the conical, the former, in addition to advantages previously mentioned, is found to be cheaper and easier to construct, it weighs less and stows in a smaller space, and, when provided with suitable swivels, does not revolve in operation.

A FIRE-PROOF FERRY-BOAT.*

BY F. L. DUBOSQUE.

The study that has been given to the fire-proof construction of permanent structures has developed buildings that may be truly considered fire-proof, and this result has been brought about by the invention and combination of materials of fire-resisting qualities. It seems to be the tendency each succeeding

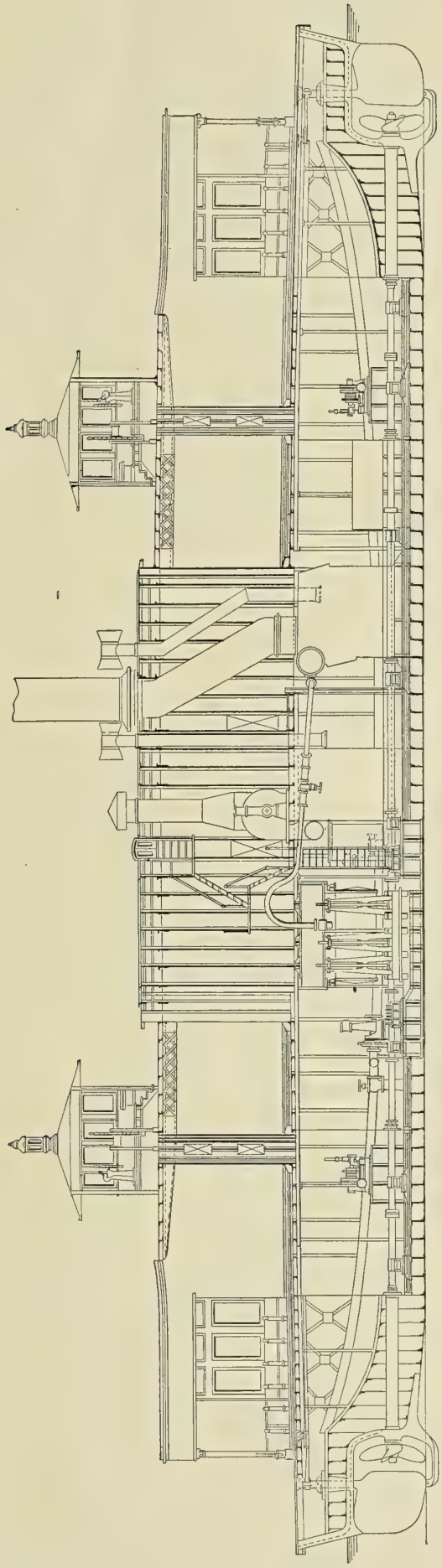

No. 18 B.W.G. Copper
No. 18 B.W.G. Copper
Glass
Section through Window Head
1½ Sash
2½ x 2½ x 5.9 Lbs.
5 Lbs.
1¾" × 1¾" x 2.2 Lbs.
4" x 1.58" x 5.25 Lbs. Channel
2½ x 2 x 4 Lbs.
Expanded Metal ⅜ Mesh.
Detail of Seat, Guard, Waist and Window Sill
Rubber Tiling
8" x 3½" x 8 Lbs.
3" x 3" x 7.2 Lbs.
3" x 3" x 7.2 Lbs. Clip
21 x 10 Lbs.
12" x 40 Lbs.
Deck Beams 5" x 2½" x 10 Lbs. Bulb
8" x 3½" x 8 Lbs.

DETAILS OF FIREPROOF CONSTRUCTION IN CABINS.

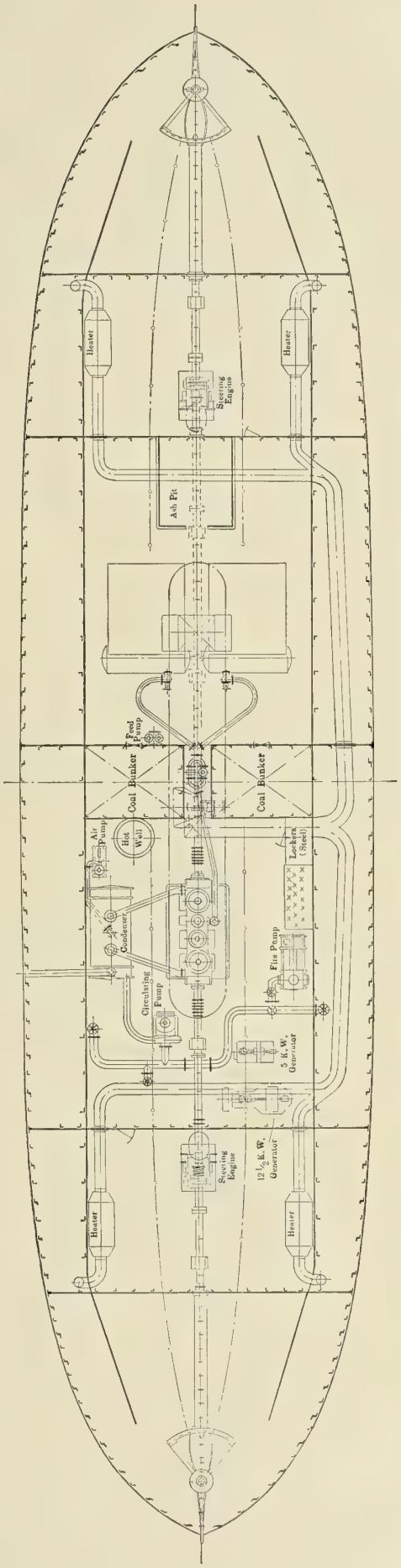
year for a greater number of people to congregate within a smaller area, not only in their homes and their business places, but on the vehicles they use for transportation. Accidents to vehicles for transportation have resulted in a considerable loss of life by fire from the fact that these vehicles have been constructed of inflammable material, and transportation companies realize the necessity of building their passenger cars of materials that will not burn. The progress in this direction has been very rapid and so successful that it is extremely doubtful if wooden passenger cars will again be constructed for use on one of the largest railroad systems of this country.

The calamity of two summers ago, which resulted in the loss of over nine hundred lives, impressed upon those engaged in the transportation of passengers by water the necessity of following the progress that has been made in the construction of fire-proof buildings, and vehicles for transportation, on land. By some of

*A paper read before the Society of Naval Architects and Marine Engineers, November 22, 1906.



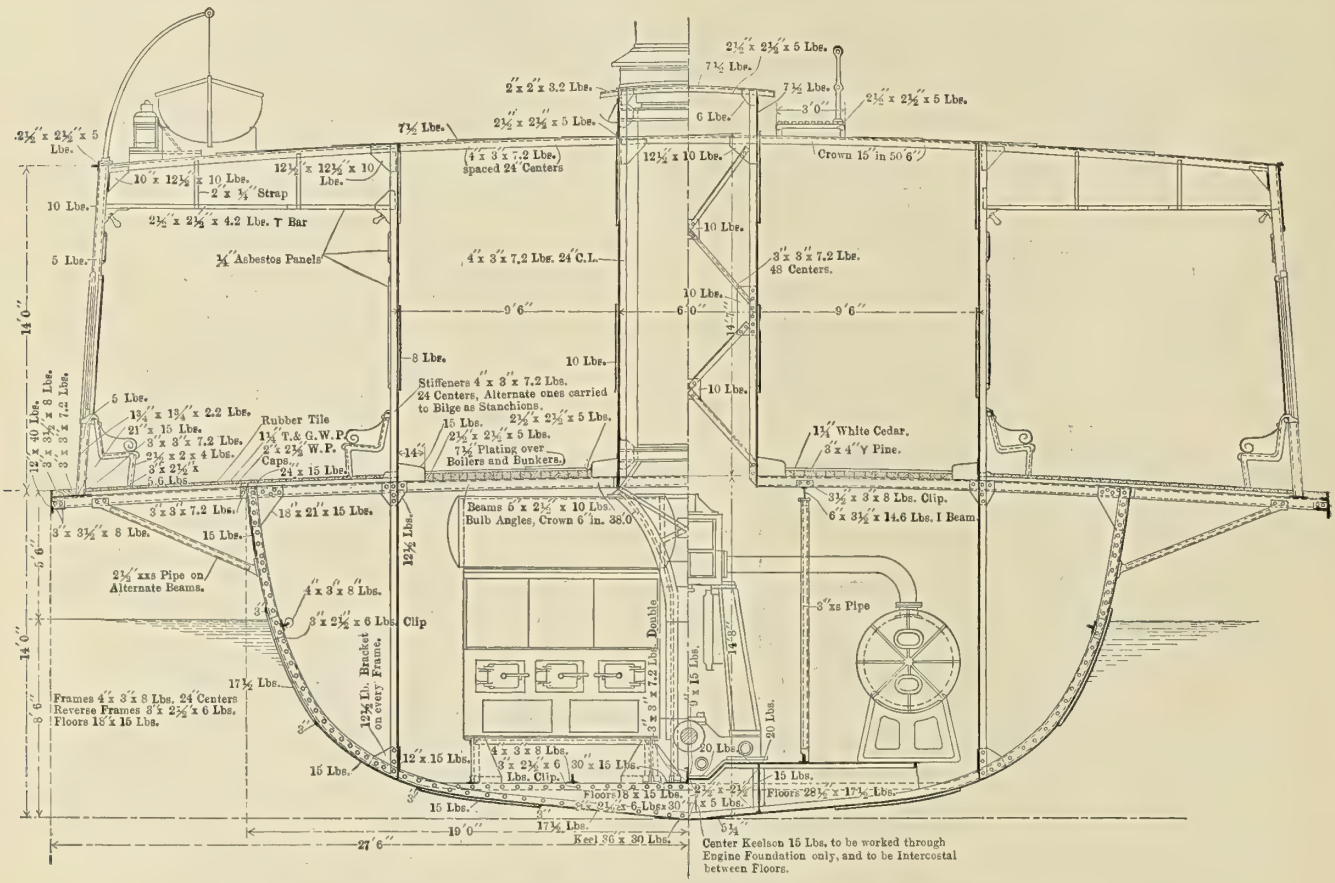
INBOARD PROFILE OF THE FIREPROOF FERRY-BOAT HAMMONTON, BELONGING TO THE PENNSYLVANIA RAILROAD COMPANY.



PLAN OF THE HOLD, SHOWING THE LOCATION OF THE VARIOUS ITEMS OF THE MACHINERY AND STEERING GEAR.

the transportation companies this feature was appreciated, and an attempt to carry it out has in a measure been followed for the past fifteen years; on the ferries of the Pennsylvania Railroad Company no ferry-boats have been built during this period on which inflammable material was placed close enough to the sources of fire to be in danger of ignition.

As the subject of our paper is ferry-boats, we will confine our discussion to this type of vessel. Fires on ferry-boats have been frequent, but the consequences usually slight, because of the vigilance exercised by the employees, and the means installed for the extinguishment of fire. The principal cause of fire has been the stowage of hot ashes in improperly constructed ash-bins or improperly constructed ash-pans beneath the boilers. Following in order may be classed imperfect electric wire construction; the accidental overturning of petticoat lamps; the overheating of the smokestack; and finally—one of the most


Crown 15" in 50'6"
Stiffeners 4" x 3" x 7.2 Lbs. 24 Centers, Alternate ones carried to Bilge as Stanchions.
7½" Plating over Boilers and Bunkers.
Beams 5" x 2½" x 10 Lbs. Bulb Angles, Crown 6" in. 38.0
1¾" White Cedar.
3" x 4" V Fine.
Rubber Tile
1¾" T.& G.W.P.
2" x 2½" W.P. Caps.
24 x 15 Lbs.
2½" xxs Pipe on Alternate Beams.
3"xs Pipe
Frames 4" x 3" x 8 Lbs. 24" Centers
Reverse Frames 3" x 2½" x 6 Lbs.
Floors 18" x 15 Lbs.
Center Keelson 15 Lbs. to be worked through Engine Foundation only, and to be Intercostal between Floors.
Keel 36" x 30 Lbs.
27'6"
19'0"

MIDSHIP SECTION OF THE HAMMONTON, SHOWING DETAILS OF THE SCANTLINGS.

annoying of the many—the throwing of lighted matches beneath the seats by passengers after lighting a cigar. Attempts to eliminate these causes of fire have been made by permitting no woodwork or other inflammable material below the main deck; by running the electric wires in iron conduits with sealed junction boxes; by forbidding the use of petticoat lamps above the main deck; by protecting the stack with an iron inclosure, and by inclosing the space beneath the seats.

Recently another and more serious source of danger has arisen in the transportation of automobiles. Fire occurring on one of these on a ferry-boat would be very disastrous, as on most of the ferry-boats they occupy a space surrounded by the lightest and most inflammable materials, that are difficult of access. After they were permitted to use ferry-boats, a rule was established that they should be stowed at either end of the boat, so that they could be wheeled overboard in case of accident. That this rule was good is proved by the fact that it has been necessary to carry out the idea. The increase in the number of automobiles to be transported, however, makes it impossible to carry all of them on the ends of the boats, and ferry-boats designed in the last two or three years have the walls and roof of the space they occupy made of metal.

The above review would seem to indicate that fire risks have been taken care of, but new dangers are continually arising, and it is clear that a ferry-boat, to be free from danger of destruction by fire, should be built of non-inflammable material, or what might be known as a fire-proof type, because inflammable materials can be used in such a way that there is no possibility of their doing damage. The amount of flame that a piece of wood will produce per unit of time depends first, upon the surface exposed, and second, upon whether the surface is laid vertically or horizontally. It is evident that a stick 12 inches square, while it contains the same volume, will not produce as much flame as twelve boards 12 inches wide, 1 inch thick; also that the flames on a surface laid horizontally will not extend as rapidly as if this surface is laid vertically. These features must be borne in mind in the designing of fire-proof structures, as up to the present time it seems to have been impossible to eliminate the use of wood.

It has been thought by many that the danger of loss of life on a ferry-boat is very remote, principally because of the boat's short route, and the experience of the past supports this view. Nevertheless, all of us were appalled at the loss of life on the *General Slocum*. This boat had better opportunities for securing a landing-place for her passengers than a ferry-boat has, yet a combination of circumstances which it is unnecessary here to discuss resulted in the most appalling disaster that has happened to any of our harbor craft; and while it may be claimed that such a combination will not happen again, the fact is indisputable that the disaster would not have occurred had the boat been of fire-proof construction.

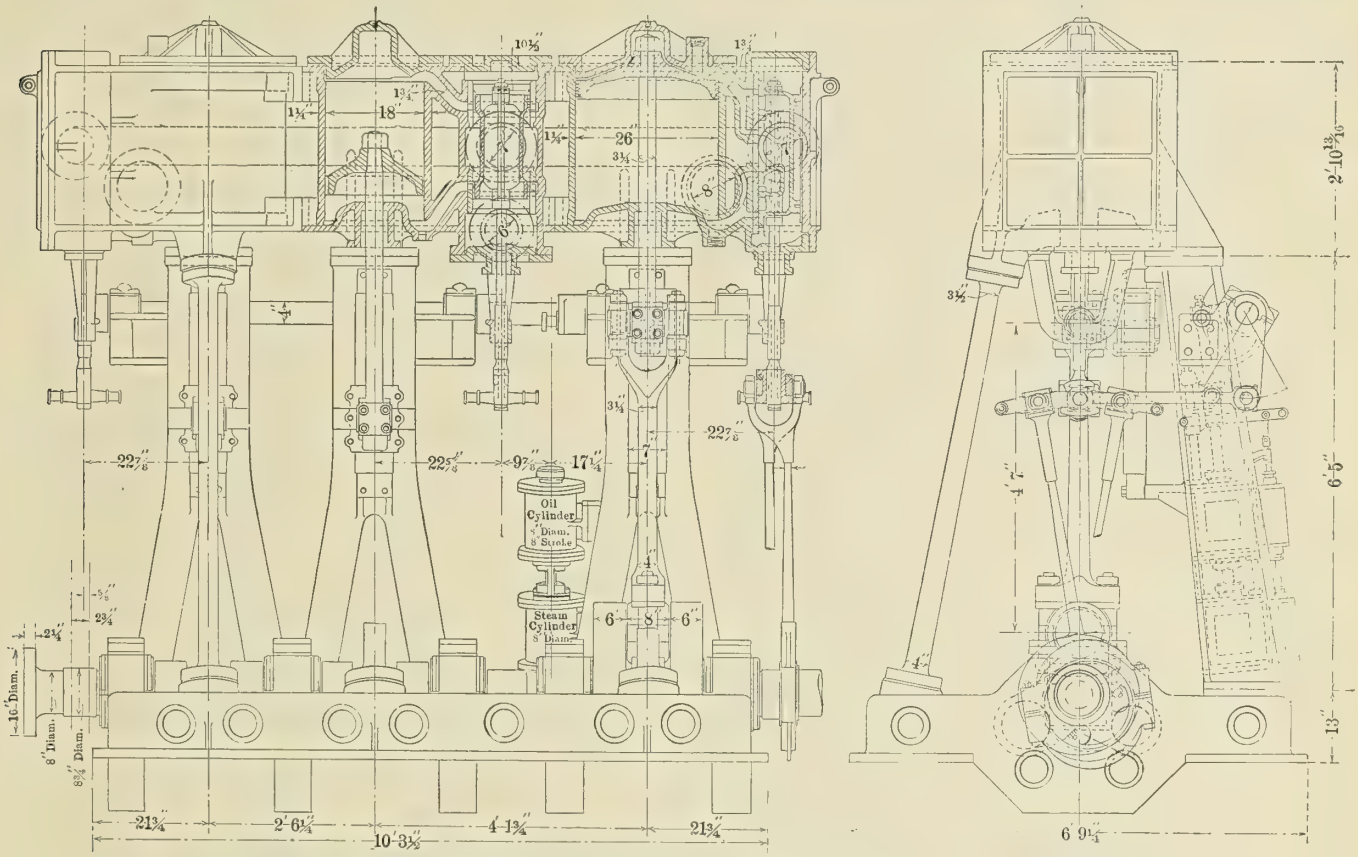
Extending further the ideas they have long had in mind, and appreciating the advantages to be gained from a fire-proof ferry-boat, the Pennsylvania Railroad Company prepared the designs

of the boat illustrated in this paper, and entered into an agreement with the New York Shipbuilding Company at Camden for its construction.

Below the main deck the design departs but very slightly from the prevailing practice, and no woodwork is used in this part of the boat. Above the main deck, steel plates and angles have taken the place of wooden stanchions, carlins and sheathing. Realizing that in this particular part of the boat wood would give sufficient strength with very much less weight than steel, it was necessary to closely study the strength of the various sections of plates and angles employed to build up the structure, and notwithstanding the fact that these sections were made as small as thought safe, it was estimated that the steel structure would weigh nearly thirty tons more than the wooden structure. This increase, however, is only about 5 percent of the total displacement of the boat.

supporting the walls of the cabin by means of narrow plates ⅜ inch thick.

The connection between this angle iron and plate is made with pieces of wood which are fastened to the angle bar with bolts, and to which the thin plate is fastened with ordinary round-headed wood screws. The panel frames are fastened to the thin plate which forms the ground of the wall in the same manner, the round heads of the screws being exposed to view. At these points a limited amount of wood is used, but it is protected from any external flame by iron plates, and the amount used is thought to be insufficient to cause any considerable damage. For instance, a lighted match alongside of an iron plate would burn itself out without doing damage, whereas a volume of kindlings set afire would cause the plate to bend out of shape; therefore, it is apparent that somewhere between these two extremes a certain amount of wood can be used in fire-proof construction



THE THREE-CYLINDER COMPOUND ENGINE, WHICH OPERATES A PROPELLER AT EACH END OF THE BOAT.

As a slight ornamentation of the cabins of a ferry-boat has been looked upon as necessary, an attempt to carry out this feature has been made by employing some of the materials mentioned in the fore part of this paper as being developed by the demand for fire-proof construction. The ceiling and side walls are almost entirely covered with a material known as asbestos building lumber, which is a composition of asbestos and Portland cement that is fire-proof, is not affected by moisture, has a reasonable degree of tenacity, and can be manufactured in large sized panels, with a smooth and even surface which receives paint quite as satisfactorily as wood. This material is formed into panels by fitting steel moldings of suitable design around its edges. These moldings are a recent production, and are made by drawing thin strips of steel 5/100 inch thick through roller dies that form the plates into the shape of section desired, and of any reasonable length. The angles, grooves and coves are drawn so sharply that when painted the moldings cannot be distinguished from the most perfect wooden molding, and the section is so uniform that joints may be accurately made. The panels thus produced are fastened to the angle iron stanchions without dangerous results. It would have been possible to have made these fastenings with tap bolts, but the great additional expense was thought to be unnecessary.

The seats in the cabin are made of drawn steel moldings supported on steel angle bars. The window sash, window sills and frames are made of wood, but the wood used is completely covered with sheet copper of No. 18 gage, and recognized as thoroughly fire-proof construction. The pieces of wood forming these parts are first molded in the section desired, then loosely wrapped with copper and both together are drawn through dies that press the copper firmly down on the wood and lap-joint the edges of the copper sheet. It is this lap-jointing that is the important feature in the operation. Wood covered with metal cannot be considered fire-proof if the edges of the material can be twisted away by heating, so as to allow the wooden surfaces to be exposed, and this particular defect has been the cause of destruction of many so-called fire-proof buildings.

The main deck of the boat is made of wood. In the cabin it is covered with interlocking rubber tile, which is a fire-resisting material, but no such protection is afforded in the team

gangways. Without enormously increasing the weight of the vessel it was impossible to find a substitute for wood that would be entirely satisfactory for this particular place. However, the surfaces of this deck are horizontal, are very easy of access, are constantly in view, and it is therefore thought that a fire occurring on them could not extend very far.

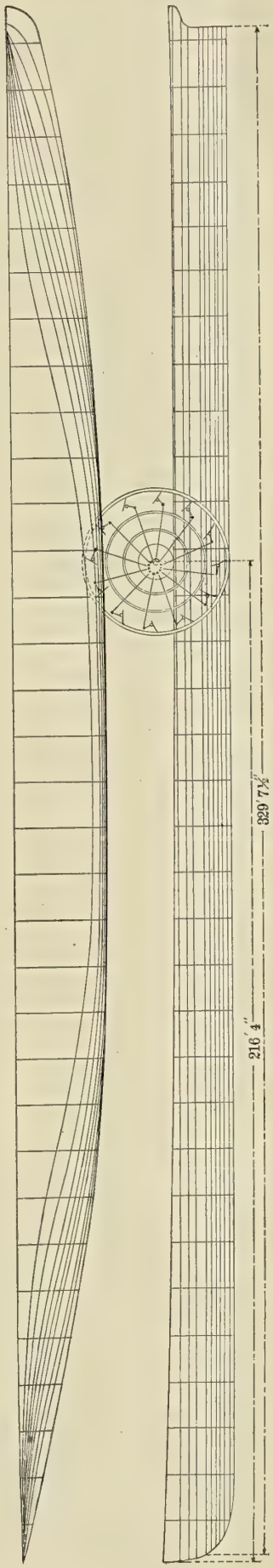
It is estimated that the cost of this boat has been increased about 7 percent by the construction applied. The interest on this amount is only about 25 percent more than would pay for fire insurance premiums, and the balance is more than offset by what might be called the cost of fire vigilance. It is expected that the cost of maintenance of this iron structure will be considerably less than of a wooden one. The greatest enemy of steel is rust, but as the wooden joiner-work on ferry-boats is usually painted about once a year to keep up appearances, it is very evident that the steel structure will be amply protected from rust if painted this often.

Aside from fire protection, the boat is divided into water-tight compartments to prevent her from sinking in the event of a collision, and water-tube boilers have been used to generate steam, for it has been the policy of the Pennsylvania Railroad Company to use only water-tube boilers on their ferry-boats for the past ten years, as there is probably no one place where a boiler explosion would cause such a loss of life as on a ferry-boat, which on its daily trips frequently carries over one thousand passengers.

This ferry-boat has been named *Hammonton,* and will be used on the ferry between Philadelphia and Camden, having been completed the latter part of November. Considerable credit is due the New York Shipbuilding Company for the enthusiasm with which they have entered into the details of construction, which appeared at the start to be very complicated, and to which they have given a considerable amount of time and study.

DIMENSIONS OF FERRY-BOAT HAMMONTON.

Length over all	168 feet 0 inches
Length outside to outside body post	167 feet 0 inches
Length, outside to outside propeller post	138 feet 6 inches
Beam, over guards	55 feet 0 inches
Beam of hull, molded	38 feet 0 inches
Depth, from top of keel to top of deck beams, amidships	14 feet 8 inches
Camber fore and aft	1 foot 0 inches
Draft	8 feet 6 inches
Displacement	625 tons
Boilers—Two of Babcock & Wilcox type.	
Length of casing	10 feet 3¼ inches
Height to center of steam drum	8 feet 9½ inches
Length of tubes inside of headers	9 feet 0 inches
Length of grate	6 feet 6 inches
Diameter of steam drum	3 feet 0 inches
Diameter of tubes	2 inches
Heating surface, combined	3,300 sq. feet
Grate surface, combined	93 sq. feet
Ratio of heating to grate surface	35.5
High-pressure cylinder	18 inches
Two low-pressure cylinders, each	26 inches
Stroke	22 inches
Indicated horsepower	600
Surface condenser, cooling surface	1,700 sq. feet
Propeller	diameter, 8 ft. 3 inches; pitch, 12 feet 6 inches
Pitch ratio	1.51
Circulating pump	6 by 6 inches
Air pump	7½ by 14½ by 8 inches
Feed pump	7½ by 4½ by 8 inches
Fire pump	12 by 9¾ by 10 inches
Steering engine, one at each end	5 by 6 inches
Number of electric lights	225
Number of seats	272



THE WATERLINES OF THE HUDSON RIVER STEAMER NEW YORK, SHOWING ALSO THE LOCATION OF THE PADDLE WHEELS.

PERFORMANCE OF THE PADDLE-WHEEL STEAMBOAT NEW YORK, OF THE HUDSON RIVER DAY LINE.*

BY PROFESSOR JAMES E. DENTON.

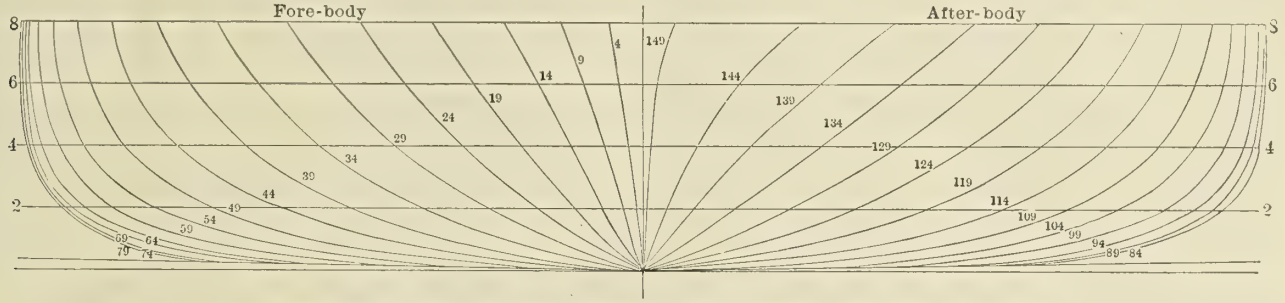
Ever since the advent of the *Clermont* made the Hudson river the birthplace of steam navigation as a remunerative art, the passenger traffic of this river has practically adhered exclusively to the use of the single-cylinder, vertical, low-pressure, paddle-wheel engine which Fulton adopted. In the development of this type of engine in day passenger service on six feet of draft, the advent of the *Mary Powell,* in 1861, represents the maximum speed attained with radial paddles, and a diameter of wheel sufficient to afford a speed of about 20 statute miles† without exceeding 25 revolutions per minute.

In the further development for speed since the date of the *Mary Powell,* the *New York,* built in 1887, represents the best which has been accomplished, with wheels about as large as those of the *Mary Powell,* but fitted with feathering paddles. In the latest development represented in the recent advent of the *New York's* magnificent sister boat, the *Hendrick Hudson,* the historical type of engine is supplanted by the high-pressure, inclined, compound system, using feathering paddle-wheels of so small a diameter that an engine speed of upward of 40 revolutions per minute is required. I have, therefore, ventured to think it appropriate at this time to present the results of speed and power trials of the *New York,* made at the request of the owners, as a contribution to the information desired in designing the new boat.

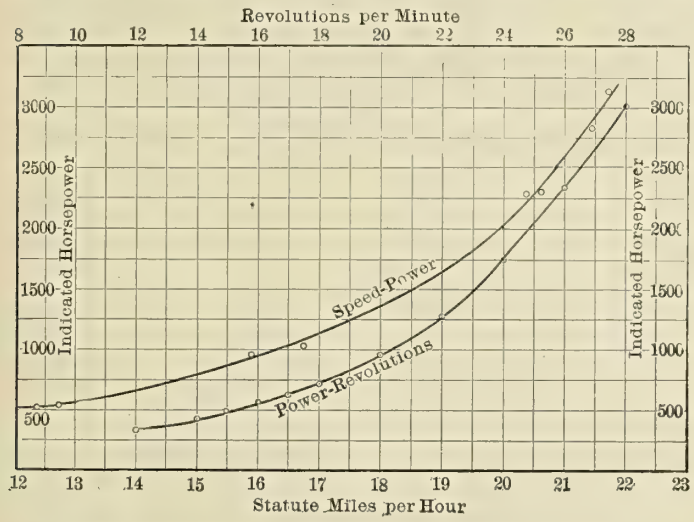
The tests were made during the spring of 1903, just after the boat had left the dry-dock for the season's service. They consisted of a progressive speed test with opposite runs over a straight course off 96th street, and a continuous river test from New York City to Poughkeepsie.

GENERAL DESCRIPTION AND DIMENSIONS.

The hull of the *New York* is of steel, with lines as shown. The engine is of the single-cylinder, walking-beam type, to which slightly superheated steam at about 40 pounds pressure is supplied by three return-flue boilers operated under natural draft, and artificial draft when necessary, by air at about 1.5 inches pressure delivered into closed ash-pits.

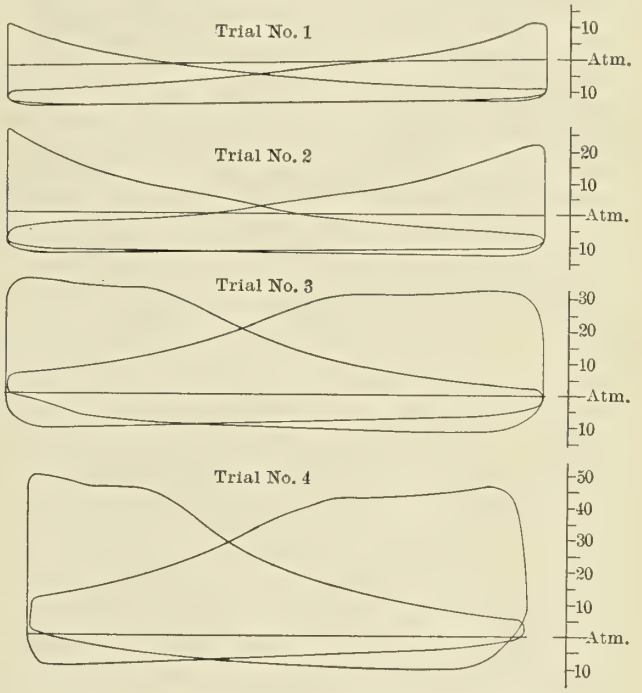


BODY PLAN OF THE DAY LINE STEAMER NEW YORK, SHOWING SECTIONS FORE AND AFT.



CURVES SHOWING THE PROGRESSIVE DEVELOPMENT OF POWER.

Diameter of cylinder	75 inches
Stroke of piston	12 feet
Heating surface of boilers, total	5,499 square feet
Grate surface of boilers, total	228 square feet
Ratio, heating surface to grate surface	24.1
Length of hull on water line	330 feet
Draft from top of keel during tests	6 feet
Beam on water line	40 feet



SAMPLE INDICATOR CARDS FROM PROGRESSIVE SPEED TRIALS.

Area of midship section	216 square feet
Coefficient of midship section	0.9
Displacement	1,240 gross tons
Block coefficient	0.548
Wetted surface	11,250 square feet
Outside diameter of paddles	29 feet 10 inches
Diameter to center of trunnions	27 feet 0 inches
Width of paddles	3 feet 4 inches
Length of paddles	12 feet 6 inches
Number of paddles	12
Dip of paddles	4 feet 5 inches

*A paper read before the Society of Naval Architects and Marine Engineers, November 22, 1906.

†The most definite information regarding the speed of the *Mary Powell* is that contained in Isherwood's paper, *Journal Franklin Institute,* Vol. 78, wherein her speed, based on observations by Mr. Theron Skeel during many trips between Kingston and New York, was 19.3 statute miles per hour at 21.8 revolutions per minute.

TABLE A.—RESULTS OF PROGRESSIVE SPEED TRIAL.

Trial	Direction	Revolutions per minute	Boiler pressure, pounds per square inch	Vacuum, inches	M. E. P.	Indicated horsepower	Statute miles per hour: Speed along shore	Statute miles per hour: Speed corrected for tide	Slip % at center of trunnions
			Throttled						
No. 1	S.	15.4	37	28	10.43	529	11.72	12.37	16.70
	N.	15.87	37	28	10.65	540	12.84	12.74	16.73
			Throttled						
No. 2	S.	19.78	38	28	15.40	973	16.83	15.90	16.62
	N.	20.80	39	28	15.56	1,035	15.60	16.74	16.51
			Wide Open						
No. 3	S.	25.53	36	26	28.17	2,297	21.70	20.39	17.15
	N.	25.84	32	26	27.97	2,310	19.10	20.58	17.38
			Wide Open						
No. 4	S.	27.59	50–43	24.5	32.26	2,843	23.08	21.45	19.35
	N.	28.18	48–47	24	34.80	3 132	19.96	21.72	20 05

PROGRESSIVE SPEED TRIAL.

This was made over a course lying between 96th street and 109th street. The lines of these streets are parallel and clearly defined, so that by running at right angles to them, about 700 feet from shore, a course is afforded 0.85 statute mile in length by the Coast Survey chart, with a depth of water increasing from 48 feet at 96th street to 68 feet at 109th street. Opposite runs were made at four speeds commencing at about 15 revolutions per minute, and ending with about 28 revolutions, the latter being the highest speed that could be maintained by the boilers.

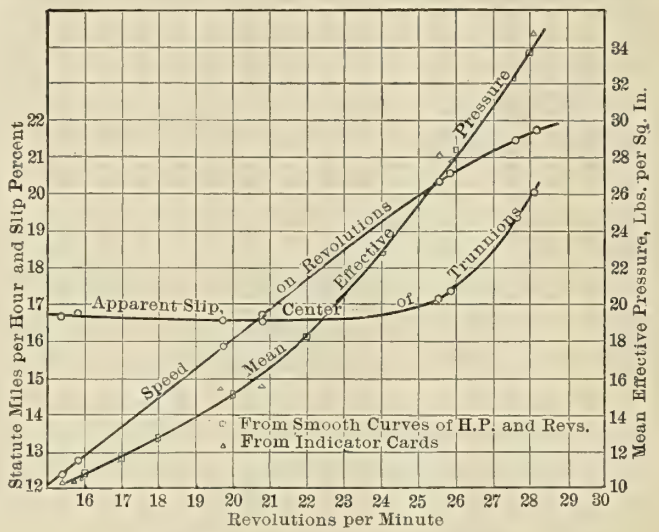
The trial speed, Table A, is deduced for each separate run, by applying to the apparent speed the tide value given by curve. The latter represents a smooth line parallel to the mean tide, but lying below these values at the higher speeds, to allow for the increasing slip shown by the slip curve, the effect of which can be computed by a modification of the tide formula. As, however, fractional revolutions were not determined, this refinement is rather chimerical.

Curves of speed, horsepower, and mean effective pressure on revolutions, and of horsepower on statute miles, are shown. Sample indicator cards are also given.

RIVER TRIAL.

This was a continuous run from Desbrosses street to Poughkeepsie, a distance of 74.21 statute miles as determined by carefully scaling the path of the boat on standard charts. The trip was timed so that the boat carried a flood tide throughout the run. The run was made in the exceptional time of three hours, thirteen minutes and twenty seconds, notwithstanding that the speed was handicapped by abnormally low steam pressure over a considerable fraction of the trip, and by several slow-downs. The detailed data are shown in Table B. The Nicholson log chart shows very strikingly how impossible it is to maintain a steady speed in a crooked stream like the Hudson river.

Column 7 of the table gives an approximate indication of the great variation of tide involved in a river trip. For instance, in the narrowest part of the river approaching West Point where the depth is over 100 feet, the tide is so strong that the


Statute Miles per Hour and Slip Percent
Mean Effective Pressure, Lbs. per Sq. In.
Revolutions per Minute
Apparent Slip
Center of Trunnions
Effective Pressure
Mean Speed on Revolutions
From Smooth Curves of H.P. and Revs.
From Indicator Cards

RESULTS OF PROGRESSIVE SPEED TRIALS.

TABLE B.—CONTINUOUS RUN DESBROSSES STREET TO POUGHKEEPSIE.
May 28, 1903. High Water, Governor's Island, 8.48 A. M.

Points	Time	Difference of time	Distance, statute miles: Total by Nicholson log	Distance, statute miles: Differences: Log	Distance, statute miles: Differences: Chart	Speed, miles per hour: Tide	Speed, miles per hour: Boat, along shore	Speed, miles per hour: Boat, corrected	Average: Revolutions	Average: Horsepower	Average: Boiler pressure	Average: Vacuum, inches	Average: Depth of water, feet	From curves of progressive speed trial, for revolutions: True speed miles per hour	From curves of progressive speed trial, for revolutions: Indicated horsepower
	h. m. s.	*m. s.*													
Desbrosses St.	8 42 0	.....	0.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
42d St.	8 51 0	9 0	2.5	2.5	2.88	2.53N	19.20	16.67	.....	.....	35*	26.5	60	.....	.....
129th St.	9 04 0	.....	6.2	.....	.....	.....	.....	.....	.....	.....	33	25.5	34	.....	.....
Fort Washington Point	9 10 0	.....	8.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Yonkers	9 26 0	35 0	13.60	11.1	13.12	3.46N	22.50	19.04	25.5*	2,240*	37*	25.3*	37*	20.37	2,250
Tarrytown Light	9 53 20	27 20	23.10	9.5	10.36	1.89N	22.72	20.83	26.8	2.620	39	25.3	33	21.12	2,670
Rockland Light	10 07 20	.....	27.65	.....	.....	.....	.....	.....	.....	.....	.....	.....	28	.....	.....
Haverstraw	10 21 0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37	.....	.....
Stony Point	10 28 0	34 40	34.55	11.45	12.35	1.55N	21.37	19.82	26.4	2,664	43	25.0	36	20.90	2,550
West Point	10 56 20	28 20	44.65	10.10	12.00	4.02N	25.42	21.40	27.7	2 843	42	25.3	110	21.60	2,975
Newburgh	11 19 40	23 20	52.90	8.25	8.40	0.39N	21.59	21.20	28.13	2.979	42	25.3	81	21.82	3,125
New Hamburgh	11 36 15	.....	58.70	.....	.....	.....	.....	.....	.....	.....	40	25.2	.....	.....	.....
Poughkeepsie	11 57 20	37 40	66.30	13.40	15.10	2.71N	24.04	21.33	27.5	2,867	39	25.2	60	21.50	3,115
Totals and Averages	3 13 20	.....	66.3	66.3	74.21	2.46N	23.05	20.59	26.63†	.....	.....	.....	.....	.....	.....

*The figures in these columns are the averages for the intervals between the points for which the tide is calculated.
†This figure is for the whole interval from Desbrosses St. to Poughkeepsie.

speed along shore is 25.42 miles, whereas the true speed as deduced from the progressive trial or from the Nicholson log, is only about 21.5 miles. It also appears that the highest revolutions did not occur during the period of highest steam pressure, and the highest speed of boat did not coincide with the highest revolutions per minute.

These inconsistencies, which are caused by variable conditions of current and channel, show that long distance river trials of speed, while affording opportunity for sensational records, are an unsatisfactory means of determining the true capacity of the boat.

PERSONAL IMPRESSIONS OF SHIP-MODEL TOWING STATIONS.*

BY PROFESSOR C. H. PEABODY.

Among the various objects of interest to the naval architect and shipbuilder which the writer had the good fortune to see during the summer just past were the several European stations for towing ship-models, which were then in operation, and it is thought that a non-technical statement of personal impressions might be interesting to the members of this society. The importance of such stations is so well recognized, and the general arrangements are so well known from memoirs in the proceedings of learned societies, and from articles in scientific periodicals, that a rehearsal of such matter would be pedantic and tedious; a statement of general dimensions and of dates of installation will be appended to this article for any who may be curious, and may not have the information at hand.

The first station visited was the Admiralty tank at Haslar, which was established in 1886, in succession to the original tank at Torquay, the date of the establishment of the original tank being 1872. Through the kindness of Sir Philip Watts, K. C. B., Chief Constructor to the Admiralty, the writer had the privilege of meeting there R. E. Froude, Esq., and of seeing the station under his guidance. Of the simplicity of manner and the scientific enthusiasm of this leading exponent of experimental and theoretical investigations in the realm of naval architecture it would be impossible to speak adequately without offending the characteristic reserve of his countrymen.

The first impression and the last impression of the station itself was the admirably practical adaptation of the means to the end. Nothing was lacking that could add to the convenience and certainty of the work of the station, but nothing was done for the sake of appearance.

The carriage of this station was designed to be drawn by a wire rope, and as its span is about 20 feet, it was necessary that it should be at once light and stiff. This result was accomplished by constructing a girder of pine wood, the individual members being made in the form of hollow boxes cemented and screwed together. There is some thought of applying electric traction in place of the wire rope and steam engine at this station and also at the station at Spezia, which closely resembles it; the station at Dumbarton follows the design of the original tank at Torquay and has the track suspended from the roof so that the span is much less and the carriage is so small and light that there is no intention of using electric traction. All other stations use electric traction much as at the Washington station.

The apparatus for applying and measuring the force required to tow a model is largely made of mahogany and gives the impression of nice discrimination in the selection of materials and proportions to give delicacy and certainty to the operation of the apparatus. It has all clearly been made under the eye of the master, who knew what he desired to do and how best to do it. When first installed the car was unduly affected by longitudinal vibrations of the wire tow-rope, an influence which did not affect the original design with its small and light car; in passing it may be mentioned that the car at Dumbarton is so small and light as to escape this influence. To obviate this defect a hydraulic cylinder and piston were interposed between the rope and the car and no further difficulty was experienced. An advantage of a light carriage as is found in all European stations is the fact that the rails, which are truly well laid and occasionally inspected, do not show evidence of any extraordinary care, such as grinding to reduce minute roughnesses.

As is well known, the models at this station (and for that matter at all European stations) are made of paraffin hardened by a small admixture of stearine. The outside is molded roughly in modeling clay, leaving plenty of stock to allow for cutting to the proper form; and the interior is determined by a basket framework of wooden splints, covered with calico painted with modeling clay to prevent the passage of the hot paraffin. When the model is cast, the liquid paraffin is run in slowly and begins to set at the bottom; water is filled in as fast as the paraffin sets, to aid in cooling and to counteract the hydraulic pressure of the paraffin. The water being the heavier fluid must be kept at a less height and this further avoids washing away the clay painted on the calico. Though the method of profiling models to the correct water-lines has frequently been described, and though the most essential feature has been brought out prominently, I am tempted to try a description, as the reality was so much more impressive than any description.

To begin with, let it be brought to mind that the model is mounted upside down on a platen like that of a planer, but which can be raised to the proper height for cutting any water-line. The revolving cutters are set at a fixed height and are drawn apart or brought together simultaneously by a pantograph arrangement that is controlled by tracing the water-lines on a drawing at a convenient scale. The tracer is a circle which at its proper scale simulates the revolving cutter; or if the ship's lines are contracted the tracer becomes an ellipse. Now, since it is difficult to draw or maintain a truly straight base line on any drawing, the difficulty is met by springing a wooden straight line to the base line. The tracing part of the pantograph has two guided points, one resting against the wooden base line and the other controlled by the hand of the operator, who in effect calipers the half widths of the water-lines, and transfers them at the proper scale to the cutters, so that the model is straight, whether the drawing is so or not, and has the correct form as determined by the water-lines. The model is always cut from the middle towards an end (bow or stern) so that the operator, in tracing a water-line, is likely (if in error) to make the model too full; a fault that can be readily corrected by repeating the operation, or may be remedied by the model-maker when he cuts away redundant material. But the tracer has a further advantage in that the platen is driven by hydraulic pressure that can be controlled by opening a by-pass valve; or rather, the by-pass is always open and the model at rest until the operator partially shuts the by-pass by pressure on a foot lever and so drives the model at any desired rate. The tracing is done by a hand-wheel that directly operates the cutters, and indirectly controls the tracer through the pantograph. The operator consequently rotates this wheel with a smooth, continuous, hand-over-hand motion, with his eye on the tracer. A few minutes' trial shows that practice makes the tracing easy and certain.

On the model are eight symmetrical reference spots that are sponsoned out beyond the ship's side and cut to a true plane on the top side as the model floats in the water. Hook gages are hung in pairs, two forward and two aft, to adjust and determine the draft, and to insure that the model is not sagged or hogged beyond a trifling amount. The displacement of a model is expected to be correct within one-tenth of one percent. An attendant thought that three-tenths of a percent would be a "lot."

Paraffin models are kept immersed to avoid straining when not in use. The temperature of the water at Haslar seldom varies much from 65 degrees, and a low temperature is considered essential for the proper preservation of models. When in use the models are likely to be slightly hogged because the top sides,

*Paper read before the Society of Naval Architects and Marine Engineers, November 22, 1906.

which are exposed to the air, are likely to be at a higher temperature than that of the water.

The most interesting feature of model experiments is the investigation of the wake and its effect on the efficiency of propulsion, and this problem is the more difficult because the wake of a model is liable to be ten percent greater than that of a full sized ship. There is further complication from the fact that the pitch of the propeller, whether that of the model or that of the ship, is open to doubt even though both are carefully made and measured. However, the wake diagrams are similar though not similarly placed, and the comparisons of model experiments and trials of ships correspond as well as the method warrants.

Some of Mr. Froude's more recent work has been on the resistance of ships among waves as described in his paper entitled *Model Experiments on Hollow vs. Straight Lines in Still Water and Among Waves.* The conclusion of these investigations will be remembered to show that for certain cruisers the best sea speeds will be obtained from ships which show some hollowing of water-lines at the bow. This conclusion is notable in that it differs from the conclusion of modern designers that hollow lines are always to be avoided if possible both for steamers and sailing crafts.

The apparatus still in place consisted essentially of a wooden diaphragm having the full width of the canal but only a fraction of its depth, and which would be given a motion approximating that of a dynamical vertical of the trochoidal wave. The waves made by this apparatus were most interesting to one who had given attention to the theory of waves. In the first place, the waves showed surface wrinkles or surface tension waves when the apparatus was first started, but these soon disappeared. The most interesting feature was that the waves which were on the point of breaking, had an angle of 120 degrees at the crest, as is indicated by Stokes' theory of irrotational waves. The form of wave profile given by this theory is much more like that of waves on the deep sea than the conventional trochoidal profile. Fortunately, the profiles approach each other as the height diminishes in proportion to the length, and we may use the various conclusions from the familiar theory for the proportions that are treated by naval architects. Again, it was very clear that the velocity of a group of waves was about half that of the individual wave, but this is a familiar phenomenon to any one who has amused himself by dropping stones into a pool.

It is interesting to know that the water in the tank is renewed only sufficiently to make up for evaporation and other losses. When the tank was first filled, a summer's growth of weeds was found to be troublesome; but that growth decreased year by year until it has ceased to be annoying.

All the European stations are modeled on the station at Haslar; and while every facility was most courteously given by those in charge it could not be expected that the work of the station and the time of those in charge should be sacrificed to the casual visitor. Each station had its own individuality, which I will try to throw into relief, avoiding tedious repetitions or comparisons.

The second experimental model station to be installed was the one at the Neven shipyard, belonging to Messrs. William Denny and Brothers, and its date (1884) preceded that of the Haslar station by two years, which gives it a peculiar interest in that it followed closely the arrangement of the first Admiralty tank at Torquay. In particular, the rails for the carriage were suspended from the roof over the tank, with only sufficient space between the rails for the convenient handling of the model and the recording apparatus. The carriage is very light, so that the longitudinal oscillations of the wire towing-rope do not give any trouble with the rope directly connected to the carriage. There appears to be no thought of substituting electric traction, nor does that appear to be convenient.

The possession of this station has enabled the firm to take a leading position in the solution of certain problems in naval architecture, such as very high speeds for paddle-boats, and the installation of steam turbines. It may be interesting to rehearse the first notable success that they owed to towing experiments. In 1888 the firm desired to bid for the construction of a fast paddle-boat, which was required to have at least 19½ knots speed on a length of 300 feet and a beam of 35 feet. At first the scientific staff hesitated when the firm expressed a desire to guarantee at least a knot more than the required speed; but after tests on several models it was decided that a speed of 20½ knots could readily be promised, and on trial the ship showed a speed of 21.6 knots. The model selected had a beam of 38 feet, or three more than that specified, which was in direct opposition to the common opinion at the time. In passing, it may be recalled that for paddle-boats the location and form of the waves which accompany the boat and come in contact with the hull, together with the location of the wheels with reference to such waves, is of prime importance, and such questions can be intelligently investigated by aid of the experiments on models, with comparatively little trouble and expense. It is most remarkable that while most explicit information based on experiments and experience now exists for screw-propeller propulsion of ships, the printed information with regard to paddle-wheels is very scanty and unsatisfactory, and requests for information, such as dimensions, revolutions and speeds, are not welcomed by those who have the information.

A member of this firm expressed the opinion to the writer that every important yard would do well to have its own tank, and said that even with their large amount of accumulated information they kept the tank busy, and could give work to another tank if they had it. How different this is from the common opinion that, if only such a tank could be installed, it might take in work for all the shipbuilders in the country. At the same time, an opinion was expressed favorable to the establishment of an "open" tank, not hampered by governmental secrecy or trade jealousy, at which scientific problems could be investigated, such as the best forms and proportions for various speeds and conditions. The need for such work was emphasized to the writer by the fact that he found those in charge of such a private station engaged in just such an investigation, while it may be fairly assumed that every well established station has that information filed away for ready reference.

The next station in point of time is that of Spezia, belonging to the Italian government, which has always shown boldness and originality in the development of its navy. As might be expected, it resembles very closely the Haslar station, and still has the car drawn by a cable, though the substitution of electricity is under consideration. An obvious feature was the substitution of brass and steel in place of mahogany, by the instrument maker intrusted with the construction of the apparatus, but good discretion was shown, and the changes need not necessarily be open to criticism. This station had the greatest interest to the writer because it, like our Washington station, is liable to have a temperature of 95 degrees Fahrenheit, and yet the models were made of paraffin; they, of course, are immersed when not in use, and tests may not be made during excessively hot weather. The opinion was expressed by Captain Bonfiglietti that the main difficulty in the use of paraffin came from the distortion due to unequal expansion of the parts of a model exposed to the air or to water when in use, and that for this reason the models should not be more than 13 feet long. On the other hand, models as long as 20 feet are made of paraffin at Berlin, where occasional high temperature is to be expected. The details of the installation of this station, and reports of important investigations, such as the influence of depth of water on speed, are given at length in a large volume published by Colonel Rota, of the corps of naval constructors, and in his paper before the Institution of Naval Architects.

They have at this station a carriage for testing two or three propellers at a time in place behind a model, and an arrangement for four propellers is under construction. In the preparation of model propellers, drawings are made at a convenient enlarged scale, which are reduced photographically to the required size.

A wooden model is then made to these drawings, which is used as a mold for casting the composition blades. This method may be contrasted with the method devised by Froude and commonly followed, in which the face of the blade is cut in plaster of paris to a true helical form; the blade is then molded in wax on this surface; then a back is made in plaster, which with the face (after the wax is removed) form the mold for the composition blade. The composition is a readily fusible alloy of tin, lead and bismuth.

Much trouble was experienced from vegetable growth in summer, but that has been obviated by using copper sulphate in the proportion of one to three hundred thousand. Incidentally, this copper salt stained the models an agreeable green tint.

The fourth station to be established, and the second for a private company, was that at Bremerhaven, belonging to the North German Lloyd Steamship Company. This has been used in determining the forms and dimensions of new ships for their fleet. Work has also been done for foreign governments and for private firms, both German and foreign. The carriage has a steel frame made of vertical tubes and diagonal ties, and appears to be light and rigid. It is driven by two six-horsepower electric motors, and was the first so designed.

At Charlottenburg, near the Technische Hochschule, is a station that is owned in common by that institution and the German Admiralty, the latter having exclusive control for certain months each year. When seen by the writer, the station was under admiralty control, and was used for the investigation of the action of a ship in a narrow channel with sloping sides, like a ship canal. The carriage is constructed of steel angle bars of small section, and appeared to be fairly light and stiff. It is drawn by a separate driving or locomotive car which had two electric motors. A new device was seen for testing four propellers behind a model, which was said to give satisfaction; it was covered with canvas and was not exhibited.

Models are made up to 21 feet in length of paraffin, and while prolonged hot weather may not be expected, occasional high temperatures are experienced. This is interesting in comparison with the limitations advised at Haslar and at Spezia. This tank has a peculiarity, which, however, is likely to soon disappear; namely, the width near the water surface is increased by a bench on each side, and at the edge of the bench is a row of columns carrying the rail for the carriage. It is proposed to carry the side wall up to the rail, doing away with the bench. It is reported that though the rail appeared by calculation to be stiff enough, these isolated hard spots give a jar to the carriage that appreciably affects the recording apparatus.

The last station to be seen was appropriately the last installed. This was at the yard of John Brown and Company, on the Clyde. It is a very close copy of the station at Haslar, closer, in fact, than any other seen, except that it has electric traction; and consequently presents fewer peculiar features. Important work has already been done, though the station has been in use less than two years. A considerable amount of attention has necessarily been given to building up a stock of information, and that work is not yet complete. True that information exists, but it is locked up in the archives of government bureaus, or the files of private drawing offices.

The writer was informed while in Paris that a station was in process of development for the French navy and has learned that it is now open for work. It follows closely the Haslar prototype, and, in fact, was furnished with apparatus by the makers who have supplied other European stations. The writer's credentials, unfortunately, did not include introduction to this station and the individual peculiarities cannot, therefore, be reported.

EXPERIMENTAL MODEL STATIONS.

Date.	Location.	Length.	Breadth.	Depth.
1884	Leven Shipyard, Dumbarton.....	300	20.	8.8
1886	Haslar	400	20.	9.2
1889	Spezia	479	19.7	9.8
1900	North German Lloyd S. S. Co., Bremerhaven	538	19.7	10.
1903	Charlottenburg	528	34.5	11.5
1904	John Brown & Co., Clydebank....	490	32.	10.

A COMPARISON OF DURAND'S AND CURTIS AND HEWINS' PROPELLER EXPERIMENTS OF 1905.*

BY EDWIN A. STEVENS.

The data is contained in papers "Experimental Research on the Performance of Screw Propellers," by Professor W. F. Durand, and "Some Results of Tests of Model Propellers," by Messrs. Curtis and Hewins.

Professor Durand used blades of elliptical outline, of pitch ratios varying from 0.9 to 2.1, and area ratios varying from 0.18 to 0.72; all wheels had four blades and were 12 inches in diameter.

Messrs. Curtis and Hewins described results obtained with 2, 4 and 6-bladed wheels, of which only the results of four-bladed wheels are available for comparison. Their pitch ratios varied from 0.4 to 1.5, and their area ratios from 0.161 to 0.5903; the diameter in this case is 16 inches.

Professor Durand's curves are expressed in W = foot pounds of work per revolution, and T = thrust in pounds, both at 100 revolutions per minute.

Curtis and Hewins' curves show "Power absorbing factor," and "Efficiency." The former is for use in formula P = Power absorbed by screw in H. P. = $0.0031216\ n\ Sd^2\ v^3$; n is number of blades, d is the diameter, v the speed in knots and S the power absorbing factor.

It was necessary therefore not only to draw cross curves, but to change the units in which the results are recorded. It was decided to reduce Professor Durand's data to S and e curves, and to the diameter used by Curtis and Hewins. For this purpose his curves were extended so as to cover an area ratio of 0.161, and their values taken off at the area ratios used by Curtis and Hewins. These values were plotted on pitch ratio as a base, using one curve for each slip, the curves being extended to take in pitch ratio 0.8. Cross curves were plotted for 0.8, 1.0, 1.2 and 1.3 pitch ratios. This reduced Durand's data to the same area and pitch ratios as used by Curtis and Hewins.

To pass from W and T, to S and e, the following calculations must be made for each slip and pitch ratio:

$$S = \frac{W \times 100}{33{,}000 \times n \times .0031216 \times d^2 \times v^3}$$

Bearing in mind that

$$v \text{ (speed in knots)} = \frac{100 \times p}{101.33}(1 - s),$$

$$\text{that } n = 4,$$

$$\text{and that } d = 1,$$

$$\text{we have } S = \frac{.243\ W}{v^3}$$

$$\text{and } e = \frac{T \times p\ (1 - s)}{W}$$

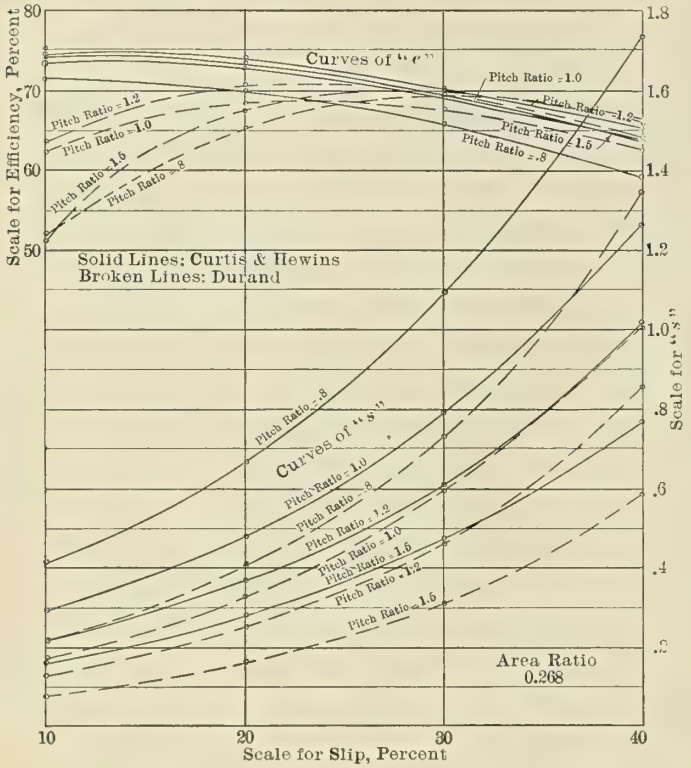
No allowance has been made for difference in outline or section of blades and diameter of hub. The latter may be neglected, in trying to account for the differences shown in the curves as thus brought to a common basis. The outline of Durand's blades is an ellipse, the variation in area being produced by changing the length of the minor axis. Curtis and Hewins' wheels were of Taylor's suggested standard outline.

For equal areas Durand's blades would have a greater width from the root out to some point beyond the minor axis. Curtis and Hewins' wheels should therefore absorb somewhat more power, but it is hardly possible that this would account for all the differences shown in the curves of S.

*Paper read before the Society of Naval Architects and Marine Engineers, November 22, 1906.

The efficiency curves are of wholly different character, though the maximum efficiency does not vary so greatly as one might expect. This leads to the supposition that the blade sections must have varied, and that in the effect of this variation most of the differences must be sought.

Professor Durand's wheels were of the same sections as those described in his paper on this subject in the *Transactions* of 1897. The blades were made to represent average practice. Curtis and Hewins, though they do not specifically so state,



A SAMPLE SET OF COMPARATIVE CURVES.

used, as I am informed, the sections shown in Naval Constructor D. W. Taylor's paper, read before this society in 1904. This section seems thinner at the root, though probably a little thicker at the tip, than full-sized wheels in ordinary practice.

To me the results seem too inconclusive, and too apt to further becloud an already much beclouded subject to warrant publication in their present form. As may well be imagined they represent a bit of hard work. In view of this fact, it seems appropriate to suggest the consideration by this society of the propriety of laying down standard methods in accordance with which future observers may report data on this and other subjects, in such form as would render them more readily available for comparison.

The Japanese Battleship Satsuma.

On November 15, 1906, the Japanese launched from the Yokosuka dockyard the first powerful battleship ever constructed in that country. This was the *Satsuma,* of 19,060 tons, being 1,160 tons heavier than the famous *Dreadnought* of the English navy. The keel was laid May 15, 1905. The vessel is said to have a length of 482 feet, a beam of 83 feet 6 inches, and a draft of 27 feet 6 inches. This makes a block coefficient of 0.603, which is sufficiently fine to permit the attainment of a speed of 18.5 knots on 18,000 horsepower.

The battery will consist of four 12-inch rifles mounted in pairs in turrets on the center line in the conventional manner; twelve 10-inch guns in pairs in turrets on the beam, and twelve 4.7-inch guns intended to guard against torpedo boat attack. Of the five torpedo tubes, four are submerged. Great enthusiasm was manifested at the time of the launching, the Emperor having been present. The vessel is said to embody lessons from the late war, the woodwork on board having been reduced to a minimum, while elaborate fire-fighting apparatus has been fitted. The upper works have been kept as clear as possible of top hamper. Details of construction are believed to follow in the main those of the *Dreadnought.* The armor belt has a maximum thickness of 9 inches, tapering to 5 inches at the ends.

Another ship of the same size is now under construction, while it is reported that a third, 3,000 tons heavier than the other two, has also been laid down. In addition to these vessels, four first class armored cruisers are under construction, two of them being already afloat. These vessels are of 14,600 tons each.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of November 12, 1906, the following percentage of completion of vessels building for the United States Navy:

			Oct. 1	Nov. 1
BATTLESHIPS.				
Nebraska	19 knots.	Moran Brothers Co.	96.71	97.
Vermont	18 "	Fore River Shipbuilding Co.	93.6	95.
Kansas	18 "	New York Shipbuilding Co.	91.	93.1
Minnesota	18 "	Newport News Co.	96.	97.
Mississippi	17 "	Wm. Cramp & Sons.	65.52	67.82
Idaho	17 "	Wm. Cramp & Sons.	62.41	64.03
New Hampshire	18 "	New York Shipbuilding Co.	53.3	54.3
Michigan	19 "	New York Shipbuilding Co.	0.28	0.85
South Carolina	19 "	Wm. Cramp & Sons.	0.0	0 6
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works.	95.7	96.1
South Dakota	22 "	Union Iron Works.	93.2	93.4
North Carolina	22 "	Newport News Co.	61.09	63.28
Montana	22 "	Newport News Co.	54.28	56.84
SEMI-ARMORED CRUISER.				
Milwaukee	22 knots.	Union Iron Works.	98.9	99.4
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works.	47.4	51.9
Birmingham	24 "	Fore River Shipbuilding Co.	47.4	50.7
Salem	24 "	Fore River Shipbuilding Co.	47.5	50 7
SUBMARINE TORPEDO BOATS.				
Cuttlefish		Fore River Shipbuilding Co.	89.	90.
Viper		Fore River Shipbuilding Co.	73.	81.5
Tarantula		Fore River Shipbuilding Co.	90.	92.
Octopus		Fore River Shipbuilding Co.	74.4	78.8

United States Shipbuilding.

The Bureau of Navigation of the Department of Commerce and Labor reports the construction during the month of September of 78 vessels aggregating 36,501 gross tons. Of this total, 10 vessels aggregating 28,397 tons, or an average of 2,840 tons, are steel vessels propelled by steam.

During the month of October the construction is reported to have been 84 vessels, aggregating 33,054 gross tons, of which 11 amounting to 26,003 tons, or an average of 2,364 tons each, are steel vessels propelled by steam.

The construction in November is reported to have amounted to 34,284 tons in 66 vessels. Nine of these, aggregating 29,289 tons, or an average of 3,254 tons each, are steel vessels propelled by steam.

In the three months in question there were respectively 4, 2 and 4 steel steam vessels built on the Great Lakes, the aggregate tonnages of which amounted to 24,996, 13,763 and 20,755 gross tons. This aggregate of 59,514 tons out of a total of 96,086 tons is no less than 62 percent. It will be seen that the average size of the 10 vessels mentioned is 5,951 tons.

The bureau reports the construction during the quarter ended September 30, 1906, of 296 vessels aggregating 102,748 gross tons. Of this total 32 vessels, amounting to 82,916 tons, were of steel and propelled by steam. Of the latter, 14 vessels of 70,107 tons, or an average of 5,008, were built on the Great Lakes, and 18 vessels of 12,809 tons, or an average of 712, on the Atlantic and Gulf coasts. The total compares with 315 vessels of 82,520 gross tons for the corresponding quarter of 1905.

MOTOR BOATS.

PART XVII.

BY DR. WILLIAM F. DURAND.

RACING RULES AND TIME ALLOWANCE.

The fundamental purpose of time allowance, based on rules for the classification of racing boats, is to eliminate such advantages as may belong to mere size or power alone, and to make possible a contest on reasonably even terms among boats of different sizes and powers. It will be remembered, from the chapter on power, that in general the larger the boat the more easily is a given speed realized. Especially is this the case with reference to the influence of increasing length. It will result in consequence that large boats, and in particular boats in which the length is exceptionally great in relation to the size, will thereby possess an advantage by such fact alone, and no contest on reasonably even terms could be held between such a boat and one markedly smaller, or with a much smaller proportion of length to general size. Again, it is generally agreed that the advantage given by horsepower alone should be eliminated from speed contests, so that among boats, for example, of the same size and of similar forms, differences in the power should not enter as a determining factor in a racing contest.

From the reverse point of view, it may be said that in speed contests every item of difference between the contestants should be eliminated except the following:

(1) Consistency and general excellence of design.

(2) Integrity and general excellence of construction.

(3) Skill in handling and in making the most of the boat as actually designed and built.

Still otherwise we may ask regarding each contestant the following question:

With the boat as it is, and assuming a thoroughly consistent and carefully studied design throughout, together with integrity and general excellence of construction and a good degree of skill in handling, what speed may be reasonably expected? If this question can be answered, then such speed will determine the rating, and the differences in such speeds will determine the time allowances for the various boats. Such allowances or corrections being applied, it will result that all differences in speed will be eliminated, except such as may depend on items (1), (2) and (3) above noted; and to the boat which excels in the combination of these three items will go the honor of victory.

It may thus result that a boat making the course at a speed of 18 knots, for example, may be beaten by another making only 16. This will mean that the latter, with reference to these items (1), (2), (3), was the better boat, and showed the better performance of the two. Of course, nothing can change the actual relative speeds of the two boats, and the owner of the faster boat has always the satisfaction of the higher actual achievement, with the possibilities for use or pleasure which such achievement may imply. These considerations are unaffected by racing rules, and remain as some offset to the possibility of the race not going to the actually faster boat.

Again, there has always been a feeling that racing rules should be so devised as to discourage the building of freaks, or of boats intended simply to gain all possible advantage from the character of the particular rule or formula for rating, and independent of the real value of the resulting boat. Rather, if possible, the rule should be so drawn as to favor the development of staunch and serviceable boats, and with the most carefully studied combination of useful features.

The general problem of time allowance involves then two distinct elements or parts:

(*a*) The determination of the speed which may properly be expected from a boat of reasonably normal and useful proportions and characteristics, and of specified size and horsepower.

(*b*) The framing of the formula in such manner that to the desired extent boats which depart widely from normal proportions and serviceable combinations shall be placed at some relative disadvantage with reference to the rule.

The first, or (*a*), states the broad problem for the normal boat. The second, or (*b*), is intended to discourage the production of freaks and racing machines. Now, referring again to the chapter on speed and power, it will be clear that the speed depends primarily on three things:

(1) The power developed by the engine and delivered to the shaft.

(2) The power utilized by the propeller and applied to the propulsion of the boat.

(3) The resistance due to the size and form of the boat.

We will consider these in order.

The power of an internal combustion motor depends on the following items:

(1) The number of cylinders, denoted by n.

(2) The area of piston, denoted by A.

(3) The length of stroke, denoted by L.

(4) The mean effective pressure, denoted by p.

(5) The number of revolutions per minute, denoted by N.

(6) The character of the cycle, represented by a factor f.

Expressed as a formula we have then:

$$H = \frac{p\ L\ n\ A\ N}{33{,}000\ f} \qquad (1)$$

Now, in comparing one engine with another, the factors L, n, A. f are matters of direct observation or measurement, and their values are readily determined. There remain N and p for further consideration.

Regarding revolutions N, we find in actual practice values all the way from 500 per minute or below to 1,000 or above; and, of course, this factor is not observable or measureable before the race, as in the case of L, n, A, and f. For comparing one engine with another it may be more convenient or useful to use the product $2N\ L$, or piston speed, rather than the revolutions N alone. Remembering then that for the internal combustion engine as used in typical motor boats the length L will usually be found from 6 to 9 inches, or 0.50 to 0.75 foot, it is clear that values of the piston speed will range from 500 up to 1,000 or above. In accordance with the fundamental nature of time allowance we should then ask—what is the value of the revolutions or piston speed corresponding to a thoroughly consistent, carefully developed design, in which reasonably full advantage has been taken of all engineering possibilities which bear upon such problems? This presupposes a well constructed engine, designed carefully throughout, and with special reference to the highest speed of rotation or piston speed consistent with the other features of the design; and combined with a propeller so designed as to permit the attainment of the designed rotative speed, and which will under such conditions efficiently transform the power of the engine into useful work of propulsion. The fact that rotative speed depends on the adaptation of propeller to boat, and, of course, on the provision of adequate power in the engine itself, should be kept clearly in mind in connection with these various relations.

Unfortunately there is no definite answer to the question outlined above. Opinions will vary, circumstances and special purposes will justify variations in the matter of speed of rotation or piston speed, and furthermore, the two types of engine—two-cycle and four-cycle—are not quite similarly situated with reference to the development of high speed. It should be noted in passing that if each designer and builder is frankly aiming at the highest rotative or piston speed which he can make effective, and all engines are of the same form of cycle, then the exact figure which may be taken as the standard is of less importance. The relative positions of a series of such boats will be the same, no matter with what standard they may be compared, and while the relative allowances will vary slightly with the standard adopted, such variation would, as a rule, be of no serious importance.

Thus, if all boats had four-cycle engines, and 800 revolutions were taken as the standard value for rotative speed, then each engine would be rated as for such speed. If the designer cannot attain it, he must suffer in diminished speed, and if he exceeds it, he gets the benefit in increased speed. With actual boats, however, there are designs for which (say) 600 revolutions may seem a proper limit, and in which the designer makes no pretense of striving to attain a higher speed. The design is consistent and carefully developed, with reference to this speed. In another design a distinct effort to realize high rotative or piston speed is made with reference to a high boat speed, and, for example, 1,000 revolutions are easily obtained. If then these two boats with different aims are both rated for power on the basis of 800 revolutions, obviously the latter will have a very marked advantage. Differences of this character cannot be properly evaluated in any scheme of rating, and any and all methods and formulas are unsatisfactory for the rating of boats in which the primary purposes of the design have not been the same.

Again, the limitations of the two-cycle and four-cycle types with regard to rotative speed are not the same, and it is therefore doubly hard to fairly relate engines of the two-cycle type with those of the four-cycle type. The two-cycle engine has large passages for the flow of vapor or gas in and out of the cylinder, but at high rotative speeds, that is, with a high number of changes per minute, it is difficult to keep the inflow and outflow separate and to realize an explosive charge in a reasonably high degree of purity. On the other hand, with the four-cycle engine, the valve openings and passages are naturally smaller, but relatively more time is given for the inflow and exhaust events. In a general way it results that the limitations in the case of the two-cycle engine are primarily dependent on the rapidity of the changes, or on the revolutions; while in the case of the four-cycle they are dependent on piston speed. High rotative and piston speeds may be and are realized with both types of engines, but it will presumably be admitted that high rotative speed in the four-cycle engine will result in a less marked falling off in the value of the mean effective pressure than in the case of the two-cycle.

To sum up with regard to rotative and piston speeds, we conclude that:

(1) The rating of engines, all with reference to the same standard revolutions or piston speed, can be fair only when all engines so rated are designed primarily for the same general purpose. Any attempt at classification will, of course, involve some vagueness of definition or interpretation, but unless there is some reasonable similarity of purpose in the designs, it is hopeless to expect any rating rule to properly relate the boats for purposes of racing.

(2) Within a class restricted to boats designed all for the same general purpose, and all with engines working on the same cycle, the exact value of the revolutions or piston speed adopted as a standard is of relatively less importance.

(3) Between engines working on the two-cycle system and those on the four-cycle, no rule can be entirely satisfactory, and any rule adopted will be sure to bear unequally in accordance with the special characteristics of the case.

Turning now to mean effective pressure, p, and referring to the earlier chapters on the engine, we find ground for the conclusion that with the same general conditions otherwise, this factor will be less for the two-cycle than for the four-cycle. The value of p depends primarily on the purity of the mixture, and in this respect the four-cycle type scores a marked advantage, especially at high rotative speeds. We shall here assume that with equally good practice in each type of engine, the value of p in the two-cycle engine should be 80 percent of that in the four-cycle. This will give the relation,

$$p_2 = 0.80\, p_4$$

Turning now to the horsepower formula above, we have:

$$H = \frac{p\, L\, n\, A\, N}{33{,}000\, f} = \frac{p\, n\, A \times 2\, LN}{33{,}000 \times 2\, f}$$

Then, putting for $2L\,N$, the piston speed, the single letter S, we have:

$$H = \frac{p\, n\, A\, S}{66{,}000\, f} \qquad \ldots\ldots(2)$$

where $f = 1$ for two-cycle and 2 for four-cycle engines.

Then, with the above understanding regarding the relation between p for two-cycle and four-cycle engines, and denoting the values in each case by the subscript 2 or 4, we have:

$$\frac{H_2}{H_4} = \frac{2\, p_2\, n_2\, A_2\, S_2}{p_4\, n_4\, A_4\, S_4} = \frac{1.6\, n_2 A_2 S_2}{n_4\, A_4\, S_4} \qquad \ldots\ldots(3)$$

Regarding the proper value of the ratio of S_2 to S_4, there is little direct information, and any value must in effect depend largely on general opinion as to the operation of the limitations on revolutions and piston speed in the two cases. With the ratio p_2 to p_4 of 0.80, which we have already assumed, we shall take as a corresponding ratio of S_2 to S_4, about 0.78, giving:

$$\frac{H_2}{H_4} = 1.25\, \frac{n_2\, A_2}{n_4\, A_4} \qquad \ldots\ldots(4)$$

Then, taking two general classes of boat—high speed and moderate speed—and the two types of engine, we have as follows:

(1) For all craft built expressly for high speed, and with four-cycle engines, we assume

$$p = 66$$
$$S = 1{,}000$$

This gives:

$$H = \frac{66\, n\, A \times 1{,}000}{132{,}000} = \frac{n\, A}{2}$$

(2) For all craft as in (1), but with two-cycle engines we shall then have:

$$H = \frac{1.25 \times n\, A}{2} = \frac{n\, A}{1.6}$$

(3) For all other craft in a single class, and with four-cycle engines, we may assume a standard value of $S = 666$. Then:

$$H = \frac{66\, n\, A \times 666}{132{,}000} = \frac{n\, A}{3}$$

(4) For all craft as in (3), but with two-cycle engines, we may properly assume the relative power as slightly greater than for the high speed class. We shall therefore take

$$H = \frac{1.3 \times n\, A}{3} = \frac{n\, A}{2.3}$$

In general we may put:

$$H = \frac{n\, A}{B} \qquad \ldots\ldots(5)$$

where H = horsepower.
n = number of cylinders.
A = area of piston.
B = factor, as below.

Values of B:

High speed, four-cycle, $B = 2$.
High speed, two-cycle, $B = 1.6$
Moderate speed, four-cycle, $B = 3$
Moderate speed, two-cycle, $B = 2.3$.

It is, of course, impossible to satisfactorily draw the line between so-called high and moderate speed. Each class shades into the other by imperceptible gradations, and any attempt, as above, to specify two classes, must be crude and unsatisfactory, and produce results on the time allowance value which cannot be considered entirely fair. On the other hand, the inclusion of all engines into one class with reference to piston speed will be no less unsatisfactory and unfair, and between the two possibilities it has seemed best to suggest, in accordance with the practice of the American Power Boat Association, the two classes as above.

TIME ALLOWANCE.

Let v_0 = speed of standard boat in knots.

v_1 = speed of any other boat, assumed as less than v_0.

Then $1 \div v_0$ and $1 \div v_1$ represent respectively the time in which each boat will go one nautical mile, and the difference between these times, reduced to seconds, will be the time allowance per mile.

Denoting this allowance by a we have then:

$$a = 3{,}600\left(\frac{1}{v_1} - \frac{1}{v_0}\right) \quad \ldots\ldots (6)$$

This amount is thus the difference in time which may be expected between the two boats in one mile, and this allowance being applied, it is assumed to bring the boats to an equal footing as regards the items properly entering into a racing contest, and to determine as the victor the boat showing the least time after correcting the actual time by this amount per mile.

In order to determine the value of this allowance, therefore, we must determine the speed which may be fairly expected. This requires the application of some form of speed-power formula. There are many such, no one of which is more than a crude approximation to the conditions which it is desired to fulfil. The more important of these are as follows:

(1) The formula should provide for the rapidly increasing demand for power as the speed increases, the boat remaining the same.

(2) It should provide for the more slowly increasing demand for power as the boat increases in size, the speed remaining the same.

(3) It should satisfy the extended law of comparison, as a result of which boats of similar form at speeds related as the square roots of their lengths will require power in the ratio of the 7/2 power of the lengths.

The common so-called Admiralty formulæ:

$$H = \frac{(\text{Midship section area}) \times v^3}{\text{Constant}} \quad \ldots\ldots (7)$$

$$\text{and } H = \frac{D^{\frac{2}{3}} \times v^3}{\text{Constant}} \quad \ldots\ldots (8)$$

fulfil the last condition, but neither of the others in altogether satisfactory degree. The index for the speed v should, as a rule, be more than 3, while perhaps 4 is too high, especially where the design is such as to cause the boat to rise partially out of the water at very high speeds. Again, for boats of increasing size at the same speed, the variation as the midship section area, or as $D^{\frac{2}{3}}$, is too rapid for the power, and if correct for the small boat would determine an excess for the large boat. This latter fault may be compensated for in a measure by introducing a size or dimension factor in the denominator. If this be taken as the square root of the length, denoted by $\sqrt{L}$, we may put the formulæ above in the form:

$$H = \frac{(\text{Midship section area}) \times v^3}{B_1 \times \sqrt{L}} \quad \ldots\ldots (9)$$

$$\text{and } H = \frac{D^{\frac{2}{3}} \times v^3}{B_2 \times \sqrt{L}} \quad \ldots\ldots (10)$$

In this form the third condition is no longer fulfilled, while the first still remains as before. It is, however, entirely possible to develop formulæ which will, in more or less satisfactory degree, fulfil these various conditions, but at the expense of simplicity of form. Thus, take the formula:

$$H = \frac{D^{\frac{3}{4}} \times v^{\frac{1}{2}}}{B \times L^{\frac{1}{2}}} \quad \ldots\ldots (11)$$

This provides for the variation of the power more rapidly than as the cube of the speed, and fulfils the other conditions (2) in reasonable degree and (3) exactly. The use of such a formula as a basis for time allowance would, however, lead to unwieldy roots and powers, and, having in view the crude and somewhat arbitrary character of time allowance at the best, it is doubtful if the apparent gain would be worth the added labor and difficulty of application. In any event, we shall here assume that it would not, and shall therefore recur to the simpler formulæ (9) and (10) above. The choice between these two turns on the relative usefulness of the midship section area and the two-thirds power of the displacement as a factor in such formulæ. We shall prefer the latter, briefly for the following reasons:

(1) It is presumably more consistently related to the power than is the midship section area, and as a function of volume takes more accurate account of variations in form than is possible for an area such as the midship section.

(2) By the use of the displacement rather than the midship section area it is more difficult to design a boat with reference to gaining a special advantage from the form of the rule.

Adopting, therefore, the formula (10), and writing the factor B without subscript, we have as follows:

$$H = \frac{D^{\frac{2}{3}} \times v^3}{B \times L^{\frac{1}{2}}} \quad \ldots\ldots (12)$$

$$v = \frac{B^{\frac{1}{3}} \times H^{\frac{1}{3}} \times L^{\frac{1}{6}}}{D^{\frac{2}{9}}} \quad \ldots\ldots (13)$$

$$B^{\frac{1}{3}} = \frac{v \times D^{\frac{2}{9}}}{H^{\frac{1}{3}} \times L^{\frac{1}{6}}} \quad \ldots\ldots (14)$$

Now, applying these values in the formula for time allowance above, we have:

$$a = \frac{3{,}600}{B^{\frac{1}{3}}}\left(\frac{1}{\frac{H_1^{\frac{1}{3}} \times L_1^{\frac{1}{6}}}{D_1^{\frac{2}{9}}}} - \frac{1}{\frac{H_0^{\frac{1}{3}} \times L_0^{\frac{1}{6}}}{D_0^{\frac{2}{9}}}}\right) \quad \ldots\ldots (15)$$

Next, applying (12) to a series of trial results, and using for D the weight W in pounds, we find as a good average value $B = 4{,}096$ and $B^{\frac{1}{3}} = 16$. We must next arbitrarily assume a speed for the so-called standard boat. This we shall take as 24 knots. Then from (13) we have, writing W instead of D:

$$\frac{H_0^{\frac{1}{3}} \times L_0^{\frac{1}{6}}}{W_0^{\frac{2}{9}}} = \frac{24}{16} = 1.5 \quad \ldots\ldots (16)$$

Substituting these numerical values in (15), and multiplying both numerator and denominator by 66.·6, we have:

$$a = \frac{3{,}600}{16}\left(\frac{66.\cdot6}{\frac{60.\cdot6\, H_1^{\frac{1}{3}} \times L_1^{\frac{1}{6}}}{W_1^{\frac{2}{9}}}} - \frac{66.\cdot6}{100}\right) \quad \ldots\ldots (17)$$

$$\text{or } a = 15{,}000\left(\frac{1}{\frac{66.\,6\, H_1^{\frac{1}{3}} \times L_1^{\frac{1}{6}}}{W_1^{\frac{2}{9}}}} - \frac{1}{100}\right) \quad \ldots\ldots (18)$$

Now the quantity $\frac{66.\cdot6\, H_1^{\frac{1}{3}} \times L_1^{\frac{1}{6}}}{W_1^{\frac{2}{9}}} = \frac{200\, H_1^{\frac{1}{3}} \times L_1^{\frac{1}{6}}}{3\, W_1^{\frac{2}{9}}}$ we shall call the rating, and denote it by the single letter R.

We have, then, in general, for any boat:

$$\text{Rating} = R = \frac{200\, H^{\frac{1}{3}} \times L^{\frac{1}{6}}}{3\, W^{\frac{2}{9}}} \quad \ldots\ldots (19)$$

The multiplication by 66. 6 or by $200 \div 3$ in (17), and in the formula for rating, (19), is simply to bring the rating of the standard boat to the figure 100. Then for (18) we have:

$$a = 150\left(\frac{100}{R} - 1\right) \quad \ldots\ldots (20)$$

If, in any case the rating R should be greater than 100, the value of a would be negative or subtractive, and for its numerical value we should have:

$$a' = 150\left(1 - \frac{100}{R}\right) \quad \ldots\ldots (21)$$

Now the values of the time allowance in the tables, given for example in the hand book of the American Power Boat Association, are simply the values of a and a' computed from the above formulæ for the various values of the rating R. The fact that we have thus reproduced the table of allowances as given in this hand book means simply that the standard rating is taken arbitrarily at 100, and the standard speed at 24, and any time allowance table based on these standards will have values as given by the equations (20) and (21) above, quite independent of the particular formula from which the rating is derived.

Another point of interest in connection with the rating is readily derived by substituting from (19) into (13). We thus find:

$$v = \frac{3\ B^{\frac{2}{3}} \times R}{200} = 0.24\ R \qquad (22)$$

That is, the speed by formula, or the reasonably expected speed, is 24 percent of the rating as found by rule. It is not uncommonly supposed that the rating is a sort of length, or that it has something to do with length. This is entirely erroneous, and as shown above, it is directly related to speed by the relation shown in (22). Hence we readily see that for any boat of rating R, the reasonably expected speed is simply 24 percent of such rating.

With regard to the value of the rating as given in (19), it will be desirable to express this in other forms, as follows:

$$R = \frac{200\sqrt[3]{H\sqrt{L}}}{3\sqrt[3]{\sqrt[3]{W^2}}}$$

or:

Rating equals 200 times the cube root of the power, multiplied by the sixth root of the length in feet, and divided by 3 times the two-ninths power of the weight in pounds. Again, to find the two-ninths power we have the simple

Rule: Take the cube root of the cube root, and square the result: or, take the cube root twice, and square the result.

To illustrate the application of this rule for rating, take the following data:

$L = 42$ feet
$W = 8{,}400$ pounds
$H = 120$

Then
$\sqrt[3]{120} = 4.932$
$\sqrt[3]{42} = 3.476$
$42^{\frac{2}{3}} = \sqrt{3.476} = 1.865$
$\sqrt[3]{8{,}400} = 20.33$
$\sqrt[3]{20.33} = 2.73$
$(2.73)^2 = 7.45$

Then $R = \frac{200 \times 4.932 \times 1.865}{3 \times 7.45} = 82.3.$

With regard to the measurement of the three items involved, the following may be noted:

L results from direct measurement, in accordance with the customary rules in force.

H results from direct measurement and computation, in accordance with the rule for power.

W for small or moderate sized boats may be determined most satisfactorily by direct weighing in running condition. Where this is impracticable, the immersion fore and aft in running condition may be carefully noted and the corresponding weight determined from the displacement, which may be found either (1) by a special computation based on measurements taken from the boat when in dock, and by methods familiar to naval architects, or (2) by a special computation based on a certified draft of the lines of the boat furnished by the builder, or (3) taken direct from a certified displacement curve furnished by the builder.

GENERAL OBSERVATIONS.

In specifying the value of the numerical factors in the formula for rated engine power, two general divisions were assumed—high speed and moderate speed; or in the terms employed in the rules of the American Power Boat Association, "automobile racing boats" and "all others." By the same rules, the automobile racing boat is defined as one whose rating exceeds ten times the square root of its load water line length. Translating this into terms of speed, by the relation explained above, this means a boat whose speed by formula should exceed 2.4 times the square root of the water line length. In this form the rule is more intelligible, as we readily see what it means in the case of any given boat. Thus most of the so-called automobile or high speed boats have been from about 40 to 50 feet in length. This means then for a 40-foot boat that the expected speed will exceed 15.2, and for a 50-foot boat that it will exceed 17. These speeds are very moderate for distinctly high speed boats, and it may be asked whether the limit of rating should not be raised to about 13 times the square root of the load water line length, which would mean a speed for the 40-foot boat of about 20 knots or more, and for the 50-foot boat of about 22 knots or more.

Again, these general divisions of high speed and moderate speed boats may be separated into subdivisions in accordance with structure, and into classes with reference to rating. Thus in the rules of the American Power Boat Association the miscellaneous division is divided into two subdivisions comprising (1) cabin boats and boats with standing awnings, and (2) hunting launches and open boats. Again, each of these with the high speed division is subdivided into seven or eight classes, according to rating.

This extended subdivision has the effect of bringing into any one class only such boats as are within about 2.5 knots of each other in expected or rated speed, and under such conditions the amount of compensation to be provided by the time allowance is reduced to comparatively small limits, and may be accepted as reasonably fair, provided only that the ratings themselves are reasonably accurate.

The general basis of the rating has been discussed in detail, and by way of further comment it will be sufficient to note the following points:

(1) The accuracy of the rating depends on two chief items—the horsepower rule, and the rating formula.

(2) Of these two, the latter is presumably on the more satisfactory basis, especially having in view the subdivision of the boats into comparatively narrow classes.

(3) The chief difficulties in providing a satisfactory formula for horsepower are:

(*a*) Uncertainty and difference of opinion as to a fair basis of rating between two-cycle and four-cycle engines.

(*b*) Uncertainty and difference of opinion as to what are fair values of the revolutions or piston speed for boats of any specified group or subdivision, and also as to the proper corresponding values of the mean effective pressure.

(4) If all those who are building engines for motor boats could come together on a definite basis of agreement as to the points in (3), there would be but slight ground for dispute as to the fairness of a rule worked through on the general basis above developed.

(5) No matter what may be the rule or basis of agreement for any one year, it is probable that revision will be needed from year to year, to keep pace with the trend of development in piston speed, in rotative speed, and in special or novel features, such as the introduction of a compressor, etc.

(6) Any rule which would fulfil ideal conditions and be beyond criticism from the engineering or scientific view point would of necessity be so cumbersome and complicated as to be quite useless for general application, and in consequence, for actual use, a rule must be employed, admittedly imperfect and approximate, and even in some cases bearing unequally on different designs, but nevertheless a rule which can be applied without prohibitive labor and which, with some attempt at agreement among those concerned as to the items in (3) above, will be reasonably satisfactory in operation.

Civil service commission examinations are announced for January 3 and 4 for vacancies of civil engineers in the Philippine service, at $1,400 per annum and upwards. Applicants should apply to the commission in Washington for forms 2 and 375.

Examination is announced for January 9 and 10 to fill vacancies in the position of computer in the Coast and Geodetic Survey at $1,000 and upwards. Applicants should ask for form 1,312.

THE DEVELOPMENT AND PRESENT STATUS OF THE STEAM TURBINE.*

BY E. M. SPEAKMAN.

MARINE TURBINES. ADOPTION IN THE ROYAL NAVY.

It was thoroughly in accordance with the progressive nature of the policy of the British Admiralty that the first official order for marine turbines should be for a vessel of the Royal Navy. H. M. S. *Viper* was launched in September, 1899, and was of exactly the same size as the numerous 30-knotters then under construction; she proved in many ways phenomenal. Her turbines developed upwards of 12,000 horsepower, and the maximum speed attained was over 37 knots. Her propelling machinery, consisting of turbines and condensers, with shafting and propellers, weighed about 7½ percent less than that of similar destroyers fitted with reciprocating engines of only half the power, and whose maximum speed was 30 knots. The *Viper* ran ashore and became a total wreck during the naval maneuvers of 1901, and this fact, coupled with the subsequent and almost immediate loss of the sister vessel—H. M. S. *Cobra*—considerably delayed the proposed comparative trials with other destroyers, and somewhat adversely affected the progress of the marine turbine.

In spite of this, two more destroyers and a third-class cruiser, aggregating some 30,000 horsepower, were built for the Royal Navy, and tried during what may be called the experimental period—1903 and 1904—and from the results obtained in comparison with sister vessels fitted with ordinary machinery, the Admiralty felt themselves justified in setting aside not only their standard types of reciprocating engine, but also all other turbine systems.

The naval estimates of 1905-6 comprised the battleship *Dreadnought* of 18,000 tons, three armored cruisers (*Inflexible* type) each of 17,250 tons, five ocean going destroyers of 33 knots speed, twelve coastal destroyers of 26 knots, and one special destroyer of 30,000 horsepower and 36 knots speed. The new royal yacht *Alexandra* was also included. The propelling machinery was confined to turbines of the Parsons type, and aggregated about 300,000 horsepower. The total horsepower for the vessels of the 1906-7 programme, in consequence of the large reduction made in the naval estimates, will be only about 150,000, giving a total of some 450,000 horsepower for the Royal Navy alone in two years.

The official reasons for the change were stated in a memorandum issued by the Board of Admiralty in July, 1906, having reference to H. M. S. *Dreadnought* in particular, and to the adoption of turbines in general, and were couched in the following terms:

"The question of the best type of propelling machinery to be fitted was also most thoroughly considered. While recognizing that the turbine system of propulsion has at present some disadvantages, yet it was determined to adopt it because of the saving in weight and reduction in number of working parts and reduced liability to breakdown; its smooth working, ease of manipulation, saving in coal consumption at high powers and hence boiler room space, and saving in engine room complement; and also because of the increased protection which is provided for with this system, due to the engine's being lower in the ship; advantages which more than counterbalance the disadvantages. There was no difficulty in arriving at a decision to adopt turbine propulsion from the point of view of sea-going speed only. The point that chiefly occupied the committee was the question of providing sufficient stopping and turning power for purposes of quick and easy maneuvering. Trials were carried out between the sister vessels *Eden* and *Waveney*, and the *Amethyst* and *Sapphire*, one of each class fitted with reciprocating and the other with turbine engines; experiments were also carried out at the Admiralty experimental works at Haslar, and it was considered that all requirements promised to be fully met by the adoption of suitable turbine machinery, and that the maneuvering capabilities of the ship, when in company with the fleet or when working in narrow waters, will be quite satisfactory."

The speed and power of warships is continually on the increase, and it seems by no means unlikely that, before long, warships will rival in speed the new Cunarders, with horsepower falling but little short of theirs. When such powers are adopted, it becomes almost impossible to obtain the requisite cylinder volume with twin engines, on account of the small height available below an armored deck. Triple screws involve a great addition to weight and space occupied per unit of power, as well as to the staff required, while tandem engines present disadvantages, well proved in the case of the *Blenheim* and *Brooklyn*. Under such circumstances, little choice seems left but to adopt a suitable type of turbine.

THE DEVELOPMENT OF TURBINES IN THE MERCHANT SERVICE.

The application of marine turbines to merchant vessels dates from July, 1901, when the *King Edward* was placed in service on the Clyde. Her performance was watched with great interest, and to the excellence of the results obtained from her and the *Queen Alexandra*, which followed in 1902, may be ascribed the revolution in cross channel boat machinery that has taken place in the last five years. The vessels are too well known to require description.

The evolution in cross channel steamers due to the turbine has been remarkable, the vessels being universally popular owing to the absence of vibration and their smoothness of motion. Commencing with *The Queen* and *Brighton* for the channel service, other orders quickly followed, and there are now no less than eighteen steamers fitted with turbines built, or approaching completion, for service between English and Irish or continental ports, of which fifteen have exceeded 21.5 knots. The *Manxman, Viking*, and the three vessels of the Great Western Railway Company, have exceeded 23 knots, while the *Princesse Elisabeth* holds the record for all merchant vessels (excepting the *Lusitania* and *Mauretania*), with 24.06 knots on trial, and even more on service. These six vessels, all about 350 feet long and 2,000 to 2,500 tons displacement, form a unique series, which is approached only by the five practically identical vessels of the *Onward* type, all built by Messrs. Denny for the South Eastern, Chatham and Dover Railway Company, and which are but slightly smaller and slower. In every case, the advantages of the turbine system in saving of weight, space, and cost of upkeep, have been most marked, as has been very well shown by tabular comparisons of coal consumption with that of the reciprocating engined vessels on the same service. The total horsepower in these channel vessels is now about 150,000.

Several steamers of the *King Edward* type, for the Thames and Clyde pleasure services, have been fitted with turbines, the small experimental set made by Messrs. John Brown & Co., prior to the building of the *Carmania*, being installed in the *Atalanta*, while eight steam yachts, aggregating about 24,000 horsepower have also been constructed.

Between the channel steamers, and the large liners that have been built, there is a class of intermediate boats, several of which have been constructed by Messrs. William Denny & Bros. for the British India Steam Navigation Co. Several vessels of 17 to 18 knots speed were constructed in 1904, and more recently the *Rewa*, of 10,000 tons, has been completed, this vessel being 445 feet in length by 57 feet in breadth, and attaining on trial a speed of over 18 knots. Her turbine arrangement is the usual three-cylinder one, and with her service speed of 16 knots her performance shows a distinct step in the application of turbines to large and comparatively slow vessels.

The *Maheno*, of the Union Steamship Company of New Zealand, is rather smaller, being 400 feet by 50 feet, with a trial speed of 17.5 knots. On service between Sydney and Vancouver—a distance of 7,500 miles—her speed is about 15.5 knots, the coal burnt per day being only 110 to 115 tons. Several other

* Abstract of a paper read October 23, 1906, before the Institution of Engineers and Shipbuilders in Scotland.

intermediate steamers are also under construction abroad. In France, a 4,600-ton vessel is being built for the Marseilles and Algiers service, and in the United States four vessels, each of 5,000 tons, with speeds of 18 and 20 knots, are approaching completion.

For large ocean-going liners, the turbine has been adopted less rapidly. The first vessels were the Allan liners *Victorian* and *Virginian,* which have now been in service for eighteen months, and during the past summer have made several excellent passages, the latter vessel having frequently broken the Canadian record, and both vessels exceed the designed speed. The record trip of the *Virginian* has been made at 17.6 knots.

A closer comparison of the relative merits of the two engines, however, will be obtainable from the *Caronia* and *Carmania,* of the Cunard line, the designs of which were published by the builders in December, 1905. In point of speed on trial, the *Carmania* exceeded that of her sister ship by nearly a knot, though the speed maintained on service is about the same, namely, 18 knots. No detailed figures are yet available for publication regarding the coal consumption, though substantial advantages are obtained in the *Carmania* in extra cabin accommodation and reduced engine-room staff. As to the cost of upkeep, it may be remarked that the *Carmania* has run for nearly twelve months without having her cylinders opened for inspection.

Two large vessels are also under construction for the Toyo Kishen Kaisha of Japan, of 18 knots speed, and about 25,000 tons displacement, for the Pacific service, while the Egyptian Mail Company has recently placed orders for two vessels, 540 feet long and of 20 knots sea speed, for the Mediterranean service, the turbine arrangement in each case being the three-cylinder one.

In point of size and interest, the large Cunarders, now completing at Clydebank and Wallsend, occupy the principal position. These vessels must attain a trial trip speed of at least 25.25 knots, and a sea speed on one complete voyage out and home of 24.75 knots. The horsepower necessary is approximately 70,000, and the enormous size of the individual parts necessary practically prohibits the use of piston engines and twin screws. A four-shaft arrangement has been adopted in this particular case, the limitations affecting piston engines of such an enormous size being largely avoided by the use of turbines.

The tremendous increase in dimensions over anything yet built has involved the most careful investigation, and it is safe to say that in no ships, hitherto contemplated, has the design been undertaken with so much care or thoroughness. The total horsepower of marine turbines in merchant vessels only, built and now on order, approaches 600,000, with an additional 15,000 of turbines of other types.

MEASUREMENT OF POWER DEVELOPED.

The impossibility of "indicating" steam turbines (in the ordinary sense) has directed attention to the measurement of brake horsepower, for it is only on this basis that their correct thermal efficiency can be determined. Several ingenious instruments have been invented for measuring the torque in the shaft, and the necessity for comparing this with reciprocating practice has resulted in some highly interesting discoveries regarding the stresses in propeller shafting when these instruments have been used on ordinary vessels.

The simplest method of arriving at the power of an electrical turbine is by the use of a water brake. Readings of pressures and speed of rotation can then be obtained in conjunction with the power, and the turbine being afterwards coupled to a generator, these pressures form an amply correct guide to the power developed. Another method is to use a simple water resistance when the turbine is coupled direct to the generator.

While the former method has long been in use for finding the mechanical efficiency of small stationary engines, the accurate determination of the brake horsepower of marine engines has been greatly neglected. As long ago as 1877,* Mr. William Froude suggested the use of a large water brake secured to the propeller shaft in the place of the screw, the trial being made while the vessel was at rest; and engines are frequently run with the propeller shaft disconnected, the frictional power running light being measured with the ordinary indicator, a method which gives ample opportunity for error. The cost of running large marine engines in the shop in connection with a brake is prohibitive, while torsional dynamometers on board ship are very difficult to apply. With the adoption of turbine machinery, therefore, it became absolutely necessary to have some method of measuring the power transmitted to the screw directly off the shaft, and all meters hitherto made have been based on the well-known fact that even the strongest shafts assume a twist under the influence of torque, and that the arc of torsion, for stresses up to the elastic limit, will be directly proportional thereto.

The work that has been done in England in this line has been due entirely to the efforts of William Denny & Bros., whose torsion meter has been widely applied to vessels fitted with steam turbines, with most satisfactory results. Access to experimental tank results is essential for the development of the full value of the data obtained, but, in any case, with marine turbines, a torsion indicator is as necessary for checking trial results as were ordinary indicators in reciprocating work.

In Germany a different form of indicator is employed. The subject of torsional vibration of shafting has received very careful attention in that country, and the types of meter employed by Frahm and Föttinger have been specially designed to secure definite records of this fluctuation of stress, as opposed to the Denny-Johnston meter, from which only the mean torque can be read; the German methods involve greater complication, but suggest some important possibilities in design.

The distance between the engine and the propeller is generally considerable, and the shaft, therefore, should not be regarded as rigid, but rather as a torsional spring, more or less elastic according to its proportions, which is kept under stress by the opposite couples at its ends. With the engine running perfectly uniformly, as in the case of a turbine against a constant resistance, the shaft would undergo a constant stress, and the torsion would therefore be constant also; but with the fluctuation in turning moment due to pressure and weight of reciprocating parts, the torsion due to the engine is far from constant. Moreover, the inevitable fluctuation in propeller resistance at the other end of the shaft increases the oscillatory nature of the stress, and the shaft is therefore subject to torsional vibration of a very irregular and complex character. Consequently, the arc of torsion is continually varying, and the shaft even in the best (so-called) balanced engine is in a state of violent vibration, which, though it may easily escape the eye of an observer, is yet instantly detected by either of the German types of indicator. To emphasize the degree of this vibration it has been proved by measurements made by Frahm and Föttinger quite independently, one with an electrical indicator, the other with his mechanical type, that the arc of torsion is even occasionally negative: in other words, the shaft and engines are at times being dragged around by the propeller, while at other moments the torsion stresses may attain three times their normal magnitude.

In the German cruiser *Hamburg* and in the turbine steamer *Kaiser* the Föttinger meter was adopted. The method of working will be easily seen from the arrangement and details given. A disk is fixed direct to the shaft in a convenient place, while a few inches from it is a second disk, carried on a tube concentric with the shaft and as long as convenience permits. (Obviously the test length is limited by the span between the bearings). These disks perform practically the same functions as those in the Denny-Jonhston meter; that is, the arc of torsion on the circumference of the shaft is small, but when carried out to the circumference of the disk is magnified in proportion. Mechanism is so arranged between the two disks that their relative movement is reproduced and magnified by the same kind of

* See *Transactions Institution of Mechanical Engineers.*

pencil arrangement that is found in ordinary steam indicators. The paper carrying the drum is also concentric with the shaft, but is placed on the other side of the fixed disk to that of the tube. The diagram is taken in the usual way.

From these diagrams may be worked out the effective torque curve at any point in the revolution, and thereby the brake horsepower, or torsional horsepower determined. Curves have been drawn giving the indicated horsepower, the torsional horsepower and the mechanical efficiency for the *Kaiser Wilhelm II* and the cruiser *Hamburg,* and are interesting and demand careful attention, for exact determinations of this loss in power are very rare.*

THE QUESTION OF RELATIVE ECONOMY AND EFFICIENCY.

The question of the relative economy of turbines and reciprocating engines, for marine propulsion and electric generation, has been the subject of very great professional attention during the last five years. In both cases commercial considerations enter largely into the comparison, and to attempt a final decision, after surveying only a component feature of the aggregate efficiency, would probably be to foster a delusion. In electrical work a direct measurement of the total thermal economy can be got by referring the steam consumption of engine and generator to the kilowatts developed at the switchboard, while the turbine economy only is shown by actual brake test figures.

In marine work, however, as far as the actual economy of the main engines only is concerned, there are, except for comparatively recent tests on naval vessels, practically no reliable steam consumption data for piston engines, builders invariably being content with coal per indicated horsepower, without water measurements, thus leaving the efficiency of both boilers and engines undetermined. The indicated horsepower, moreover, is but a poor guide to the power delivered to the screw, and it is only during the last three years that the torsion meter has enabled this to be taken. Again, in spite of the most weighty and influential arguments, both scientific and commercial, only three experimental tanks exist in Britain whereby the important data of resistance and wake values, etc., can be determined. It is not, therefore, an easy matter to give a definite scientific analysis of the comparative performances of two exactly similar ships, even if in commercial development work it were always desirable to do so, and recourse must be had to comparisons on a broader basis.

As far as actual steam consumptions are concerned, a figure of 14½ pounds per equivalent indicated horsepower was obtained in the *Turbinia,* while in the *King Edward* and H. M. S. *Cobra* it was about 16 pounds for all purposes, and in H. M. S. *Viper* 15 pounds. H. M. S. *Amethyst* obtained a consumption of 13.6 pounds, under these conditions, and all these figures compare well with the performance of the notoriously efficient R. M. S. *Saxonia,* wherein 14.3 pounds was the service figure.

An objection to turbines was raised at the outset, on account of their consumption increasing as the speed of rotation diminishes. As a matter of fact, this increase is very slight for the first 12 percent, but then becomes greater, owing to the simultaneous decrease of power. The use of cruising turbines for the lower speeds has assisted to restore the relation between blade speed and number of rows which is essential for good performance, and down to nearly half speed the turbine is better than the piston engine. A complete series of the results of the performance of the cruisers *Amethyst* and *Topaze* was published in *Engineering* in November, 1905, and the comparative features are corroborated by the trials of later vessels.

While the performance of reciprocating engines has remained almost stationary during the last four or five years, that of the turbine is continually improving, with the added knowledge and experience of constant development.

* For further reference to this subject, the papers of Dr. Föttinger, to the German Society of Naval Architects, contain practically all the published information on the question of effective torque.

MULTIPLE SCREWS.

The original difficulty encountered in the application of turbines to marine propulsion was in the design and arrangement of propellers for high speeds of rotation. The *Turbinia* was originally fitted with one shaft and one propeller, but it was found impossible to thus efficiently absorb the power, and recourse was had to multiple shafts and screws driven by a turbine in series. By this means the power per shaft was reduced, and a smaller propeller made feasible. With a given pitch ratio, the absolute pitch was also reduced and higher revolutions obtained; with the smaller diameter an increased head could be got, which admitted a higher thrust per square inch of blade area, or conversely, less blade area for a given total thrust.

Following this idea to its logical conclusion and subdividing the power over several shafts, smaller turbines were obtained with a correspondingly increased overall efficiency. The question then became the exact harmonization of the propeller and the turbine for maximum propulsive efficiency, and as more experience was obtained, the excessive multiplicity of propellers, two and three per shaft, was gradually discarded, as it became evident that no sacrifice of turbine efficiency was involved by slower revolutions, provided that the other proportions of the turbine were suitably modified. The almost universal practice at present is to adopt one screw per shaft and to arrange the turbine to suit; only in very exceptional cases would the use of tandem propellers be justified.

The number of shafts depends largely on the power developed; three shafts are preferable where the turbine proportions admit of their use, but in very large installations the individual size of the cylinders is reduced by having four, the governing feature being the proportions of the blading.

AUXILIARY MACHINERY.

Considerable modifications have been found desirable in the proportions of condensers and air pumps for working in conjunction with turbines, due to the greatly increased volume and reduced temperature of the steam. With well designed apparatus, a vacuum of from 27 to 28 inches can generally be maintained with about one square foot of surface per indicated horsepower, and a circulation at 70 degrees F. of thirty times the feed water. A vacuum, however, of from 27 to 28 inches will effect a saving of about from 5 to 6 percent in the steam consumption of the main unit, but to obtain this, a higher ratio of cooling surface to horsepower—possibly 1.4 square feet—must be allowed; as well as a considerable increase in the quantity of circulating water—never a difficult matter in marine work, where, however, the surface is rather less. A proportionally larger air pump should be employed as well, but the additional power required for this and the larger circulating pump will not exceed from 1 to 1½ percent on the total power, leaving a net gain in economy of about 4½ to 5 percent, due to the high vacuum.

For vacua above 28 inches, pumps of ordinary construction are unsuitable, and the desirability of using (when convenient) the highest possible vacua, demands the employment of greater refinements. It is desirable to maintain the temperature difference between the cooling water leaving the condenser and that due to the vacuum as small as possible, and by the help of the "vacuum augmenter" this can be reduced to below 5 degrees F., even with high rates of condensation per square foot.

The action of the intensifier is to draw off the residual air to a much greater extent than is possible with ordinary pumps alone, and the condensation takes place with much greater rapidity, and allows a great reduction in the cooling surface, provided that the circulating water is not diminished in volume, and that the velocity through the tubes is kept about five feet per second, the total quantity being equal to at least fifty times the feed water.

The following table illustrates the gain of energy due to these higher vacua, assuming adiabatic expansion from 150 to 1½ pounds absolute:

Vacuum, in inches	26	27	28
Temperature, degrees F	126.5	116	102
Volume per pound, cubic feet	137.5	177.5	256
B. Th. U.'s available per pound	277	293	312
Increase in B. Th. U.'s	...	16	19
Increase percent	...	5.77	6.48

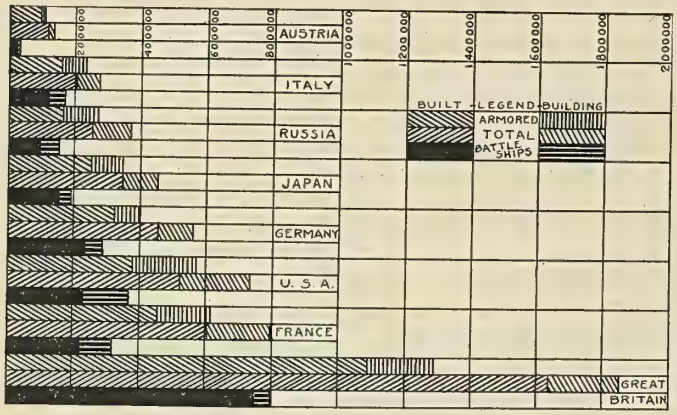
To obtain a similar increase in available energy by merely increasing the pressure above 150 pounds, compared with reducing it from 27 to 28 inches, it would be necessary to go up to over 200 pounds absolute, while in the case of the 26-inch vacuum it would be necessary to go to over 250 pounds, and either pressure would greatly increase the weight and cost of turbines and boilers.

The increase in steam volume involves much larger exhaust pipes than were usual, and it should be noted that the upper tubes in the condenser need to be much more widely spaced, to allow an easy flow of steam around them. On account of the lower hot well temperatures, it is generally desirable to fit feed water heaters fed by steam from the exhaust of the auxiliary engines.

Turbine driven auxiliaries are frequently suggested, and have occasionally been adopted for fans, while several of the channel steamers, some large warships, and the new Cunarders, are fitted with turbo-electric lighting sets, thus obviating the vibration so frequently set up by the dynamo engine.

Sea Strength of the Naval Powers.

The Office of Naval Intelligence of the Navy Department in Washington has recently issued a statement showing the number and displacement of warships built and building of the eight principal naval powers of the world. The tables do not include vessels over twenty years old unless they have been reconstructed and re-armed since 1900. Neither do they include vessels the construction of which has been authorized but not begun. Transports, colliers, repair ships, torpedo depot ships, converted merchant vessels, and yachts are not included; neither are vessels of less than 1,000 tons, except torpedo craft of over 50 tons. The tonnage of the various powers at present, as well as the tonnage which would be the case were vessels now building completed, are shown in the following table, and it is seen that the order of rank at present would not be changed by the completion of vessels under construction.



GRAPHICAL REPRESENTATION OF THE NAVAL STRENGTHS OF EIGHT POWERS.

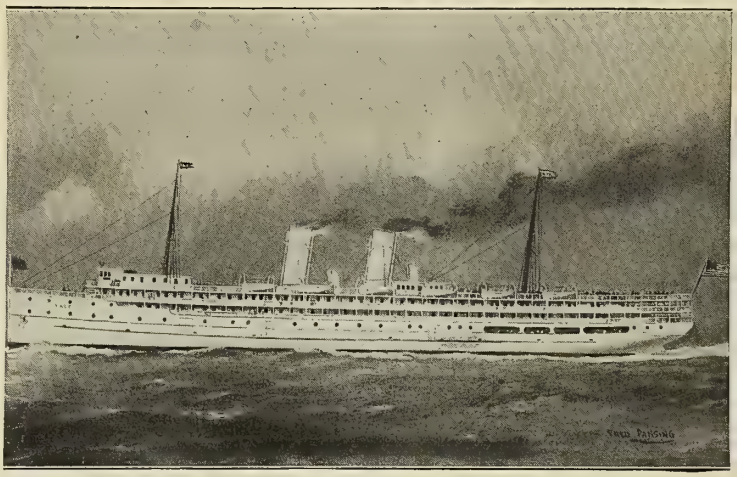
Nation.	At present.	Under construction.	Total.
Great Britain	1,640,765	211,089	1,851,854
France	609,937	189,320	799,257
United States	525,970	205,226	731,196
Germany	457,480	110,680	568,160
Japan	348,141	104,250	452,391
Russia	254,040	121,885	375,925
Italy	202,993	82,324	285,317
Austria	113,527	17,200	130,727

First class battleships, which include all those of 10,000 tons and upwards, contain, of course, the main elements of naval strength. The table shows that the tonnage under this heading now under construction for the United States navy is considerably greater than that for any of the others, being 136,948 tons, as compared with 95,440 for France, 58,600 for Russia, 52,800 for Germany, 49,700 for Italy, 49,350 for Great Britain, 38,950 for Japan and 10,600 for Austria. Next in point of view of interest are armored cruisers. Those under construction for Great Britain aggregate 149,750 tons, against 66,940 for France, 56,700 for Japan, 56,360 for the United States, 47,000 for Russia, 25,660 for Italy and 23,000 for Germany.

The diagram shows graphically by the shaded areas the tonnage at present in service, while the tonnage under construction is shown just at the right of that in service. The total length of diagram in each case will, of course, represent the total tonnage built and building for each power. Three diagrams are given for each nation: First class battleships; total armored vessels, including battleships, coast defenders and armored cruisers; and the total tonnage, as per table.

The Turbine Steamship Yale.

When the question was discussed of constructing two steamships for the Metropolitan Steamship Company to make the run between New York and Boston in fifteen hours, or between 5 o'clock in the evening and 8 o'clock the following morning, thus maintaining an average speed of approximately twenty-three statute miles an hour, and making them the fastest steamships engaged in American Atlantic coast service, steam turbine engines were decided upon for their propulsion. The builders of the *Yale* and *Harvard* have long studied the features of steam turbines, and have the utmost faith in their adaptability to ocean steamship service. That they were correct in their conclusion as to what the *Governor Cobb* could do in the way of speed, economy of operation and in the lessening of the vibration which is a feature of all screw steamships, is now proved.



THE YALE, AS SHE WILL APPEAR WHEN COMPLETED.

The two ships are of steel double hull construction, their hulls being divided into many compartments by watertight bulkheads and double bottoms, thus establishing a great factor of safety. It is intended that the quarterdeck, or social hall, which passengers enter upon boarding the steamer, shall be most comfortable and rich in its furnishings. Upon this deck will be located the purser's office, package rooms, news stand, barber shop, etc., while from this deck also the dining hall will be entered. The dining room will be spacious, and, being open to outside view, will insure the maximum of cheerfulness and ventilation. The forward part of this same deck, as well as its midship sections, will be fitted to accomodate freight and for machinery inclosures.

From the quarterdeck an artistic staircase will reach to the grand saloon deck above, and another from that to the gallery saloon. On these two decks will be located the staterooms. These rooms will be more than ordinarily large, and will be fitted with every convenience. There will be forty parlor and bathroom suites, together with about 275 other staterooms. In the number of rooms with baths these ships will be unique, in that they will have more rooms with private bath and toilet accessories than have any vessels of their size yet constructed for service in American waters. On the hurricane deck will be located an attractive writing and smoking room, as well as a café. These rooms will be most attractively equipped, and because of their location it is expected that they will become very popular.

The space below the main deck will be taken up by berths for passengers, by the boilers and machinery inclosures, and by the kitchen, pantries and officers' messrooms. The aim of the management will be to have the dining room service, with its accessories, in keeping with what travelers in these days expect, while every feature of the ships, which have most delightful waters and attractive geographical situations as a route, will appeal to those who appreciate the comforts, conveniences and service which are looked for in modern hotels.

The decorations and furnishings of the main saloons will be done in the colors of the universities after which the vessels are named. The electrical equipment will be in accord with the latest achievements in the electrical world, while the plumbing and steam heating will be of the best from the standpoint of sanitation and convenience. In fact, in every particular, the *Yale* and the *Harvard* will be complete and thoroughly up-to-date.

The general dimensions of the ships are as follows:

Length over all	407 feet
Breadth over guards	63 feet
Draft of water, loaded	16 feet
Space between inner and outer bottoms	3 feet
Accommodations for passengers	800
Express freight capacity	600 tons
Motive power (triple-screw Parsons steam turbines)	10,000 h. p.

The *Yale* was launched from the yard of the Delaware River Iron Shipbuilding and Engine Works, at Chester, Pa., December 1, 1906, and has been taken to the W. & A. Fletcher Company works at Hoboken, N. J., where the machinery will be installed and the vessel completed. The ships will go into service about June 1, 1907.

THE LAUNCHING OF THE 10,000-HORSEPOWER TURBINE STEAMER YALE.
(By courtesy of *The Marine Journal.*)

The Technical Publicity Association, the membership of which is limited to those who have charge of the advertising of manufacturing and other concerns, has appointed a circulation committee to collect information about trade and technical journals. There has been so much deception on the subject of circulation by publishers that INTERNATIONAL MARINE ENGINEERING welcomes the appointment of this committee, and trusts that it will do its work exhaustively, and not forget to meet or make a full report, as so many similar committees have done that have been appointed by other associations interested in technical advertising.

Announcement has been made that the Hamburg-American Line has just contracted for two steamers, each of 20,000 tons, for the Hamburg-New York service. They are expected to make about 15 knots, and will be named respectively *Berlin* and *Chicago*. It is stated that these steamers have already been built by Harland & Wolff, of Belfast, for the International Mercantile Marine Company, but have now been turned over to their German competitors.

INTERNATIONAL MARINE ENGINEERING

Published Monthly at
17 Battery Place · · New York
By MARINE ENGINEERING, INCORPORATED
Christopher St., Finsbury Square, London, E. C.

TERMS OF SUBSCRIPTION

	Per Year	Per Copy
United States, Canada and Mexico	$2.00	20 cents
Great Britain and Ireland	10/6	1/
Other countries in the Postal Union	10/6	1/

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Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 5th of the month, to insure the carrying out of such instructions in the issue of the month following. If proof is to be submitted, copy must be in our hands not later than the 1st of the month.

The edition of this issue comprises 8,700 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand.

Who Said Bennington?

A question which we discussed at some length last year has been again brought forcibly to our attention by our learning through authoritative channels that one of the recent first class battleships of the United States navy went to sea a short time ago with only one commissioned officer detailed for engineering duty. We suppose that there were a number of warrant machinists on board, and that the engines were made to function in a proper manner, but the spendid encouragement given to men entering the corps of warrant machinists in the navy—the great opportunities open to these men in the way of advancement to commissioned rank—and the general extension of courtesies and consideration to them, have not as yet resulted in the elevation of the service to such an extent as to give us under the heading of warrant machinists men of the very highest technical training and experience and understanding, such as the operation and care of the main and auxiliary machinery on a modern warship imperatively demand.

The present case seems to be identical with one to which the attention of the Editor was called a year ago by a retired engineering officer of the United States navy, in which that officer stated that the battleship of whose machinery he had had charge had engines indicating about 12,000 horsepower, and that his assistants were entirely from the corps of warrant machinists, there being no commissioned officers available to support him in the duty. Rather than be subjected to the tremendous strain devolving from the responsibilities of handling machinery under such circumstances, this officer left the service, and is now engaged in private practice. As a contrast to the condition of affairs above mentioned, he told the Editor that the first ship of which he was chief engineer had machinery of only 800 horsepower, but that that machinery was in charge of himself as chief, and three or four commissioned officers of the engineering department as assistants. It goes without saying that what has happened once may happen again. This remark applies not only to the practice of sending to sea ships with a wholly inadequate engineering force, but also to accidents of the character which occurred in July of 1905 on board the gunboat *Bennington.*

The Naval Architects' Meeting.

On another page will be found an account of the fourteenth annual convention of the Society of Naval Architects and Marine Engineers, held in New York during the latter part of November. Abstracts are given of all the papers which it is not our intention to publish, and a brief *résumé* of the salient points of the discussion is included. The discussions were of particular interest, bringing out as they did both the strength and the weakness of each paper, and of the various topics and constructions discussed. Six of the fifteen papers were found sufficiently interesting along our particular lines to merit publication in full, and four of these will be found in the present issue, the other two being held over until next month. We believe that, by giving our readers thus the cream of the papers and discussions, we are serving them to the best possible advantage from the information elicited at the meeting.

The fact that we have elected to allow some of the papers to pass, without publication in our columns, by no means signifies any lack of merit. On the contrary, those of the papers dealing with implements of war, in the shape of warships, guns and armor, were of extreme interest and technical value. Their sole applicability, however, to military purposes makes them of less direct importance to our readers than is the case with papers dealing with mercantile constructions. It is by the latter that civilization is best advanced, but the peculiar exigencies of modern national life have required that the others attain the high development which they now possess.

The Performance of the Steamboat New York.

When the Hudson River Day Line undertook to construct a new steamer for service between New York and Albany, tests were made upon the steamer *New York,* built in 1887, for the purpose of determining the speed possibilities on the form as then constructed. It is not often that we are enabled to lay before our readers so complete and comprehensive a description of trial results on a full sized steamer as in the present case. Not only are the lines given in such shape that a model

could be built from them, but also the various coefficients affecting the form of the hull are included, and the results in power developed and speed attained are set forth in the tables. Results of this character in such completeness are of the utmost importance to both the naval architect and the marine engineer, in the formulation of new designs based upon the results of their progenitors. The paper, therefore, may be said to form a very notable addition to our stock of information upon the subject of resistance and propulsion.

Fire-Proof Ferry-Boats.

The paper published in another column upon the above subject is one deserving of very careful attention. Ferry-boats are perhaps more easily made fire-proof than is the case with most other types of marine construction, but the fact remains that very few such boats now in service are of such a construction as to merit this term. The method carried out in the *Hammonton* seems to have been simple in applicaton, and it is believed that the extra cost in money and weight involved in thus rendering the boat proof against the inception and spread of an ordinary fire, will be found to be more than repaid by immunity from disturbances in service. Not only will there be a saving in the insurance bill, and probably in the bill for repairs to damages caused by fire, but there will be the added sense of security which would prevent the spread of a panic on board in case anything should happen which might otherwise lead to a suspicion that the vessel was about to burn.

The discussion brought out the fact that fire-proofing is not applicable in such measure to the magnificent passenger steamers now plying upon our sounds and rivers, and that it will not be so applicable until improvements are made in the materials used and in the methods of fitting them. These improvements will have to take the form of both decreased cost and decreased weight before the floating hotels above mentioned can be rendered as secure against fire as is the case with the ferry boat under description.

This fact, however, does not by any means preclude the possibility of making extensive improvements in the vessels as now constructed, and we expect to see boats of this type built within a few years in which fire resisting material will be used to such an extent as to allay in the minds of passengers all apprehension of serious conflagration.

The Japanese Navy.

Much interest has recently been manifested in the Japanese navy, by reason of the fact that a brief diplomatic discussion between the Japanese government and the United States government was magnified by the newspapers in the latter country to such an extent as to make it appear probable to their readers that war must inevitably ensue. There is probably not the slightest likelihood of any such eventuality in the near future, but the interest in the naval power of the Japanese government is none the less acute.

Our leading article this month consists in a description of one of the two latest battleships placed in service in Japan, and incidentally one of the most powerful battleships afloat. A short note in another column records the recent launching in Japanese waters of the first battleship yet built in that country. The present strength of the Japanese navy in first-class battleships ready for service is eight. It will be recalled that at the opening of the war with Russia, Japan had six such vessels in service. Two were lost during the war by reason of contact with submarine mines, while the flagship of the squadron was sunk afterwards by an accidental explosion of her own magazine. The latter ship has been raised, but we believe is not yet again in service. Three were captured from the Russians, and two have now been completed in England.

In addition to this fleet of battleships, Japan possesses a splendidly efficient and homogeneous squadron of armored cruisers, nine in number, constructed in England (four); France (two); Germany (one), and Italy (two). One of the French-built ships was captured from Russia. These vessels are all of upwards of twenty knots speed, the best being of about twenty-three knots. All are fitted with 8-inch and 6-inch guns, in addition to which one of them has one 10-inch gun; and all range in size from 7,400 to 9,850 tons. They possess on the average about the same armament as has been fitted to the six American cruisers of the *California* class, each of which displaces about 13,700 tons, and in speed are little inferior to the latter vessels.

New construction in Japan includes two first class battleships, briefly described on page 28, and four large armored cruisers. All six ships are of very great power, both offensive and defensive, and will add markedly to the strength of the Mikado's navy. It is presumed that the *Mikasa* will shortly be again in service, which will raise the fleet to a total of eleven first class battleships and thirteen splendid armored cruisers; in addition to a number of less powerful battleships and cruisers as a secondary line of defense. The effective tonnage has recently been given as 348,141 in service, and 104,250 under construction, a total of 452,391 tons displacement.

Motor Boats.

With the chapters in this issue covering racing rules and time allowances, the serial entitled Motor Boats, by Professor Durand, which has been running since the issue of July, 1905, has come to a termination. The work, taken as a whole, forms a splendid exposition of the subject, taking up the various features of both design and construction, and in the latter chapters the handling of the boats. It is to be issued in book form, and will be on the market soon after this number reaches our readers.

Lloyd's Shipbuilding Returns.

In connection with the report upon the extent of construction under way in Great Britain at the end of September, 1906, Lloyd's Register published a curve showing the historical development of its growth from the beginning of the year 1882 until the present time. It will be seen that a very decided falling off has taken place during the quarter ending September 30, this being a greater drop than had been experienced in any quarter since June, 1884. The total mercantile shipping under construction under the current date included 478 steam vessels of a total of 1,253,531 gross tons, of which all but one were of steel; and 34 sailing vessels of an aggregate of 11,236 gross tons, of which 20 were steel. The vessels under construction include 3 of upwards of 20,000 tons, these being, of course, the *Adriatic, Lusitania,* and *Mauretania;* two others of more than 15,000 tons, and four more of upwards of 10,000 tons. None of the sailing vessels included exceeds 2,000 tons in size.

Of the vessels under construction, 386, aggregating 1,014,564 tons, are for the British empire. The remainder, 126 vessels, aggregating 250,203 gross tons, are for foreign powers. These are scattered all over the world, including powers in all of the grand divisions. The United States is down for 3 vessels aggregating 1,800 tons.

Besides the mercantile shipping mentioned, reports show 47 warships under construction, of which 40 are for the British navy, and seven for foreign navies. Of the former two are first class battleships, nine are first-class armored cruisers, 18 are torpedo boat destroyers, and 11 are submarine boats. All of these except four of the cruisers are building in private yards. Of the foreign vessels, three are cruisers and four are destroyers. The aggregate British displacement is 180,325 tons; foreign displacement, 23,020 tons.

Partial returns for foreign countries show under construction in the United States (excluding the Great Lakes) 79 vessels of an aggregate of 148,912 tons. Reports for Germany show an aggregate of 90 vessels covering 263,902 tons. French construction is given as 28 vessels aggregating 40,380 tons. Holland is credited with 23 vessels of an aggregate of 50,874 tons. Italy shows 22 vessels amounting to 91,778 tons. Japan has 15 vessels aggregating 44,978 tons. Norway has 34 vessels aggregating 30,216 tons. Other powers are shown as having under construction smaller amounts.

The Register reports lost and missing during the quarter ended June 30, 1906, a total of 139 vessels, amounting to 121,542 tons. Of this total 60 vessels, aggregating 78,536 tons, were propelled by steam, and 79 vessels, amounting to 43,006 tons, by sail. As is usual in figures of losses of vessels, the bulk of the losses are made up of vessels smaller than the average in service. The average steamer lost was of 1,309 tons; sailing vessel, 545 tons.

Lloyd's Register has recently pointed out the remarkable growth in recent years in steam tonnage and the constantly increasing size of steamships. During the last fiscal year the society classed 662 new vessels, aggregating 1,412,645 tons. Of this total, 652 vessels amounting to 1,408,579 tons were steamers, and 10 vessels aggregating 4,066 tons were to be propelled by sails. The steamers averaged 2,160 tons each, and the sailing vessels 407 tons. As compared with the preceding year, there is shown to have been an increase in steamers aggregating 218,810 tons, this increase representing a gain of 18.4 percent. The sailing vessels, however, have fallen off from 11,058 tons, the loss of 6,992 tons being 63.2 percent. It is noted that there were classed during the year 39 vessels of over 5,000 tons each.

The society has been giving some attention to new types of prime mover, 14 vessels propelled by steam turbines having already been classed, while 4 turbine yachts are also included. Eight other turbine steamers are under construction for classification, including the two mammoth Cunarders, and two vessels of over 13,000 tons each, under construction at Nagasaki. The use of gas engines for marine propulsion has been brought to the attention of the society, particularly in connection with producer gas plants. A vessel is being built on the Tyne of sufficient size to offer reliable data as to the working of powerful engines under this system.

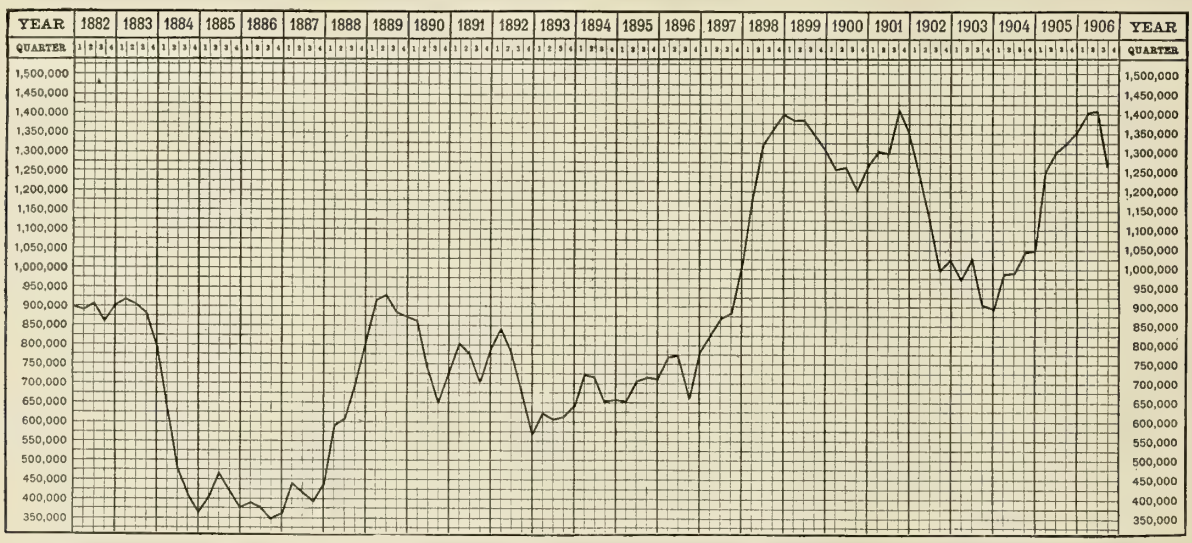


DIAGRAM SHOWING THE GROSS TONNAGE OF MERCHANT VESSELS UNDER CONSTRUCTION IN THE UNITED KINGDOM.

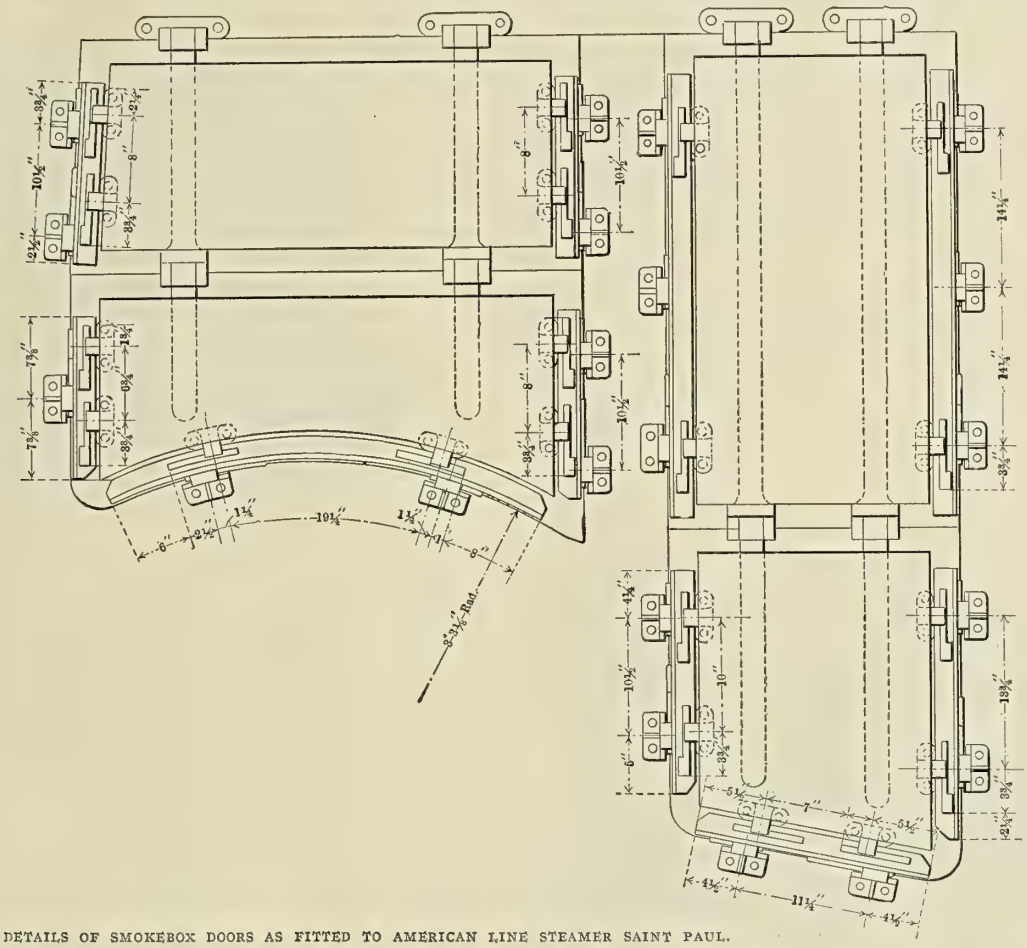
ENGINEERING SPECIALTIES.

An Airtight Smokebox Door.

On the next page we present a detailed drawing showing the latest type of Silley's patent smokebox door, which has just been fitted to the boilers of the American Line mail steamer *St. Paul.* This system of fastening has apparently solved the old trouble with leaky doors. What is claimed for this invention is increased efficiency with both forced and induced draft, increase in economy, and the total stoppage of the continued expense for upkeep charges in straightening buckled doors. These patent smokebox doors have been running something like two years in some of the large mail ships, including the Cunard liners. At the present time the boilers of the *Mauretania* (of which we gave an illustration in our November number) and the *Lusitania* are being fitted on this system.. They are also being fitted in the White Star liner *Adriatic.* It is said that the cost of fitting these smokebox doors in new installations is little, if anything, in excess of the old style of fitting.

The principle of the fastener is very simple, and consists of angle iron bars extending the whole length of the three sides of the door. These bars are attached to the door in such a way

that they can slide along its edge for a distance of from three to four inches, the standing leaf of the angle being on the outside edge of the door. Two or more wedge pieces are riveted to the standing leaf of the angle bars, sockets being secured to the smokebox, into which the wedge pieces will slide on moving the angle bar in a direction parallel with the edge of the door. The effect of this is a wedge action, which forces the angle iron hard down against the edge of the door, and brings it into close contact with the smokebox all along its length, the angle iron bars between the wedges acting as girders, and effectually preventing any possibility of the door's buckling when it becomes unduly heated, which constantly happens with forced draft.



DETAILS OF SMOKEBOX DOORS AS FITTED TO AMERICAN LINE STEAMER SAINT PAUL.

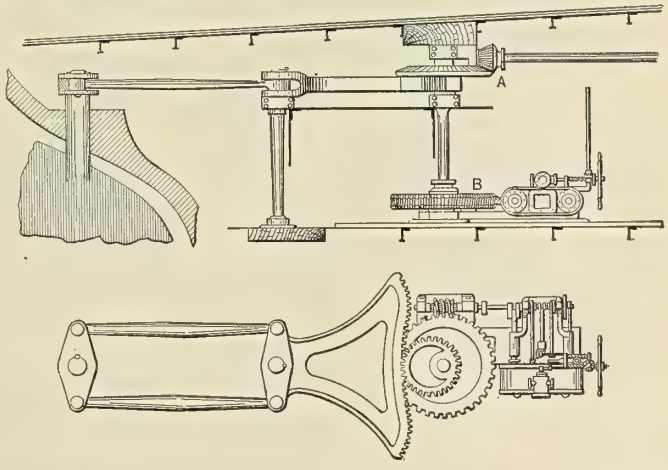
The keeping of smokebox doors tight may not at first appear a matter of much importance, but every engineer will admit that a leaking door, where natural draft is used, spoils the draft more or less by admitting cold air into the stack and cooling the ascending gases, with the result that it is more difficult to keep steam, the fires require to be worked more, and coal is wasted. With forced draft the result of leaking doors is different. In this case dust and smoke are blown out around the door, this dust covering the boilers and everything in the stokehold. It is even blown into the engine room and up the fidlies, making a very dirty ship. The owners of this invention are the Air-Tight Smoke Box Door Syndicate. W. C. Wallace, 17 Battery Place, New York, is the American representative.

Portable Electric Drills.

A number of special features of the light drills placed upon the market by the Light Electric Motor Company, Ltd., of Seven Kings, Essex, England, include automatic feed, side boring attachment and ball bearings. The drills are among the lightest on the market for the character of work for which they are designed. The automatic feed is not of importance until the hole reaches a depth of over one inch, but under such circumstances it will lessen the labor item and reduce the time of boring, and, by permitting one man to operate two machines, reduce the cost of boring. The side boring attachment permits holes to be bored within one-fourth inch of a beam or corner, and the automatic feed can be made to operate here as elsewhere. The lubricating arrangements provide for a long and continuous lubrication, while the margin of strength provided is said to be ample.

Harfield's Compensating Steering Gear.

A steering gear placed upon the market by Messrs. Harfield & Company, of Mansion House Buildings, London, E. C., has been compared with one of the ordinary screw gear in so far as the force is concerned which is necessary to operate the gear, and the strain on the rudder head has been carefully measured.



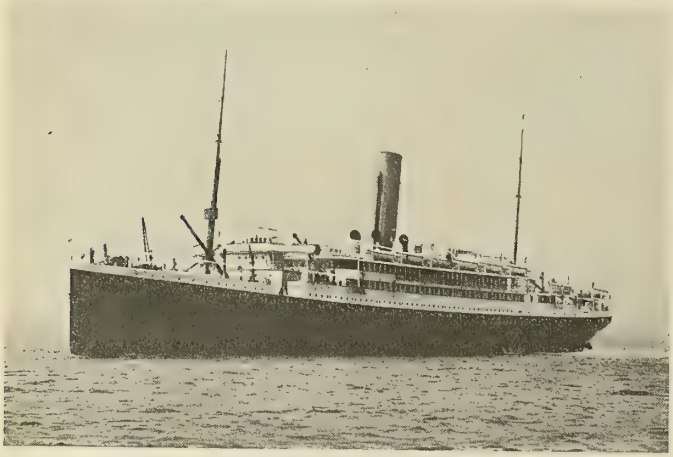
As will be noticed from the illustration, a special feature of the gear includes a toothed eccentric in mesh with a toothed cam of such a form as to be always in proper touch with the eccentric.

The particular design of this eccentric and cam is what has reduced the pull required upon the steering machinery at considerable angles of inclination from the center line of the vessel. A maximum pull seems to be reached when the rudder is at about 25 degrees from the center line, after which the pull falls off quite rapidly. This is in contradistinction to the effects experienced with the ordinary type of gear, where the pull shows a rapid increase with increase in angularity of the rudder.

The drawings show that when the rudder lies amidships and is gradually moved sideways the leverage of the engine gradually increases, until, when the rudder is full over this leverage is a maximum, with the movement of the rudder decreased in speed for a constant speed of engine. In tests between this gear and ordinary screw gear it is claimed that it took two sailors thirty seconds to put the ordinary rudder over forty degrees, and ten seconds to return it amidships. With the Harfield compensating gear, one sailor is said to have put the rudder over forty degrees in fifteen seconds, and to have got it back in four seconds.

The Welin Quadrant Davit.

In our issue of September, 1906, we gave a brief description of the Welin quadrant davit and its modus operandi, and on page 223 of our issue for June, we illustrated these davits, as applied to the new French Line flyer *La Provence*. We now note that the Royal Mail Steam Packet Company, Ltd., have fitted these davits



on board their four latest liners, one after the other, of which vessels we give an illustration of the *Amazon*, a sister of the *Aragon*, which we described at page 411 in our issue for October, 1905.

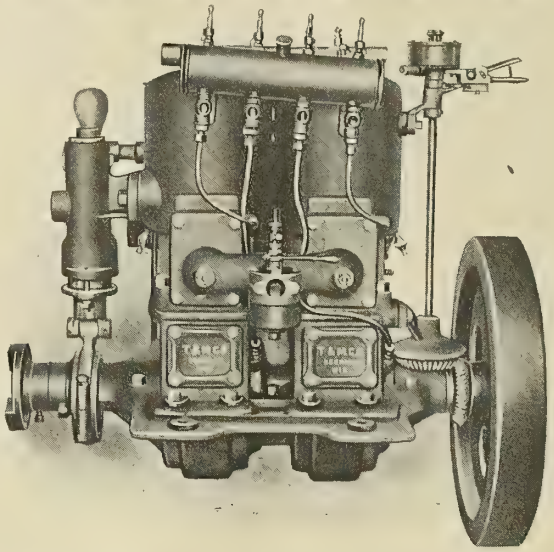
We are informed by Mr. Welin (Hopetown House, Lloyds avenue, London, E. C.), that the number of sets of davits supplied has increased from 2 in 1901, to 44 in 1902, 128 in 1903, 158 in 1904, 304 in 1905, and 548 in ten months of 1906.

Gasoline Marine Engines.

The engines designed and built by the Termaat & Monahan Company, Oshkosh, Wis., embody novel and original features, most of which are covered by patents. All of the engines take in the charge of vapor and air at the transfer port, so that alcohol or even kerosene can be used, as the hot cylinder walls surrounding the transfer port will not permit the vapor to condense while entering. On the single cylinder engines a patented condenser for the exhaust gases is attached to the cylinder. This device is a large expansion chamber, with a water spray inside which condenses and cools the hot gases, and also keeps all exhaust pipes cool. This action is automatic, and needs no attention.

The timing lever is a simple device arranged just back of the fly wheel. By its use any desired speed can be had, and it is said that the engine can be reversed as easily as a steam engine. The crank pin has positive lubrication by means of a grease cup attached to the end of the crank shaft, making it unnecessary to have oil in the base.

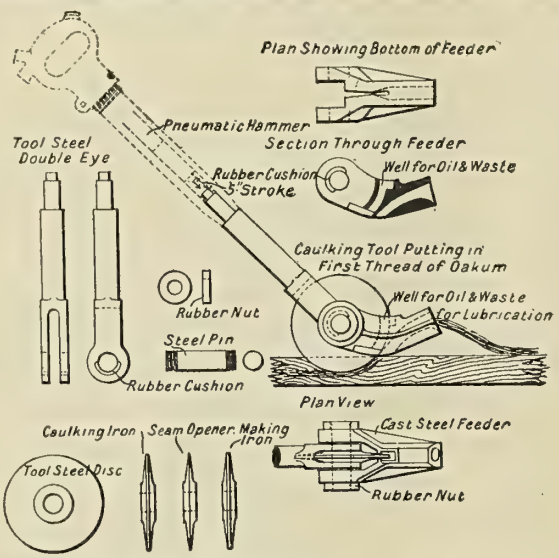
The double, triple, and quadruple cylinder engines are made in sizes of 7, 10, 15, 20 and 30 horsepower. These engines are reversible, but a reversing clutch can be supplied when desired. This, however, is not recommended, because a friction clutch is supplied with the large engines which allows the propeller to be



disengaged when desired. These engines have the water sprayed expansion muffler, and a reversing and speed-changing lever and commutator mounted at the top of the front cylinder, so that the engine can be handled and reversed very easily. A float feed carbureter is supplied. The oiling system for the crank pins is novel and extremely satisfactory, because it affords a positive oiling of this important bearing. The engines have large ports, and are capable of high speed, and are said to do excellent work in speed launches, being built neither too heavy nor too light.

A Deck Calking Tool.

The usual method of calking the wooden deck of a ship is by hand. It is expensive as well as laborious, and in recent years has given way, to a considerable extent, to more expeditious methods, which involve the use of machinery. A neat tool for this purpose has recently been placed on the market. It is known



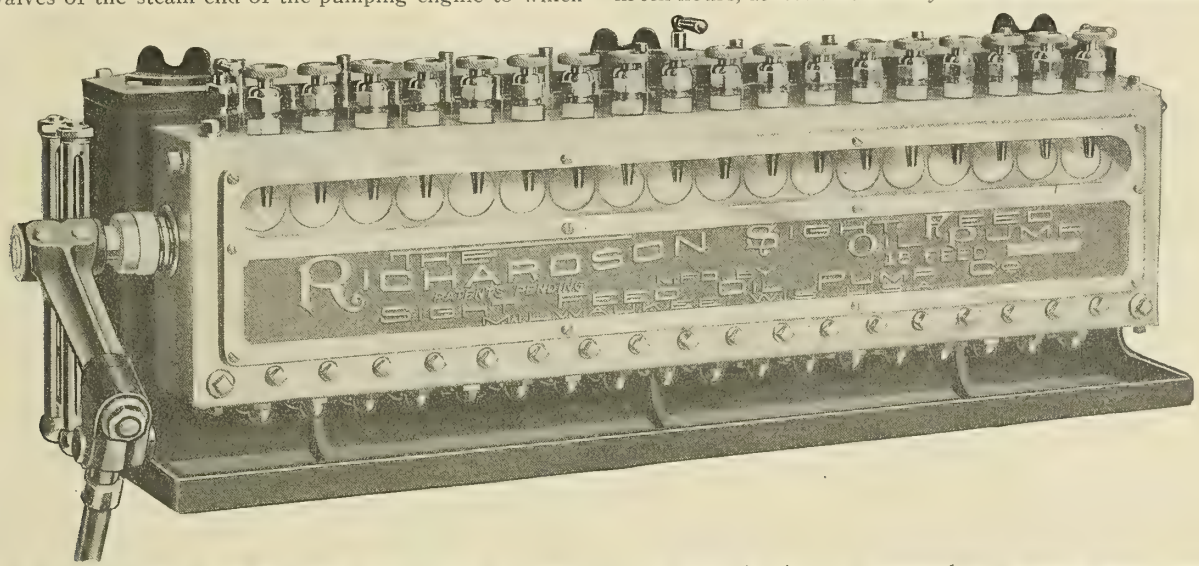
as the Thor pneumatic deck calking tool, and is constructed by the Independent Pneumatic Tool Company, of Chicago and New York. The illustration needs little explanation. The apparatus consists essentially of two parts, the feeder and hammer. The latter is a standard pattern pneumatic hammer. The feeder is

made of cast steel, and is arranged to be fitted to the rest of the apparatus by means of a steel pin, which passes through a double eye-piece, through which the power of the hammer is transmitted. To minimize injury to the bearings, owing to the action of the blows, a rubber cushion is placed in each eye-piece and also in each eye of the holder.

The pin acts as a spindle for the calking disks, of which there are three kinds. The seam opener is used to open the seam to the required width to receive the oakum. Then the calking tool is employed to insert the first calking thread. Finally, two threads of oakum are calked down on the top of the first thread by means of a third tool, called the maker. The oakum is laid down on the seam in long lengths, and one end threaded through the nose of the feeder. As the feeder is moved along, the oakum is automatically picked up. The machine is capable, so it is claimed, of doing much more work than it is possible to do by hand with ordinary tools, in fact, it is said that two apprentice carpenters can calk 690 feet a day with two tools. Further, the firm states that for drumming decks one apprentice can do 900 feet in one day.

Sight Feed Oil Pumps.

The eighteen-feed pump illustrated has been constructed by the Sight Feed Oil Pump Company, Milwaukee, Wis., and is said to be the largest pump of this type ever built. Each feed has its own independent pumping mechanism, and in addition there are three other pumping mechanisms, whose office it is to circulate the oil from the reservoir to the feed valves, the excess flowing back into the tank. Eight of the feeds carry engine oil to the bearings of the engine, six feeds carry cylinder oil to the cylinders and valves of the steam end of the pumping engine to which



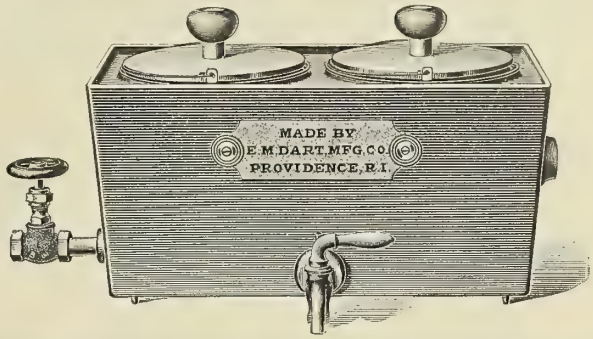
the device is to be applied, and the other four carry air compressor oil to the cylinder and valves of the gas pumping end of the unit.

The reservoir is divided into three compartments, thus enabling the pump to handle the three different kinds of oil without intermixing. The circulating plunger for the two end compartments is situated in the end of the pump. The third circulating plunger, which handles the oil in the middle compartment, is situated in the back of the pump body, midway between the sixth and seventh feed valves. This arrangement enables the construction of oil pumps to handle almost an indefinite number of different kinds of oil. In cases where it is not feasible to obtain proper movement for the pump lever, a motor is supplied, which may be driven by either compressed air or steam.

Steam Glue Heater.

The device illustrated is constructed by the E. M. Dart Manufacturing Company, Providence, R. I., and is of much use in pattern shops and other places where wood is used for construction purposes. The particular example herewith consists of a steam box 15 by 8 inches, by 7½ inches deep, and containing two kettles holding each two quarts.

The cooking and heating of glue by this device is rapidly performed, by combining all the essential features in one arrangement. The ordinary device for this purpose is generally supplied with a heating coil within the steam box for boiling the water, necessitating the frequent renewal of water lost by evaporation. In the illustration, a perforated seamless brass tube extending



the whole interior length of the steam box admits the water that has condensed in the connecting steam pipe to flow into the steam box when steam valve is opened. From this source comes the supply of water, that always remains fully half the depth of steam box, all surplus running off through an opening provided in right hand end. The draw cock is a convenient arrangement for obtaining hot water, which is an important aid in accomplishing the object sought. The range of service can be regulated to furnish cooked glue, from thirty gallons to a teaspoonful, in ten hours, at less cost than by other methods. The covers can be used when kettles are removed, to prevent steam escaping into room. The raised edge around the box prevents water flowing over that might accumulate by excessive boiling, and a pipe within the box connecting with the top provides an opening for the water to return again.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 352.—In a triple expansion Sullivan engine with Marshall valve gear, cylinders and stroke 6½ by 10 by 16 by 10, all piston valves, what is the right amount of lead for each cylinder, and at what degree from the center ought the exhaust port to close for right amount of compression at from 200 to 250 revolutions, with initial pressures of 165, 70 and 32 pounds, with diameters of valves, H. P. 3 15/16 inches; I. P. 4 inches; L. P. 5 17/32 inches, and vacuum 25 inches? W. O. A.

A.—The best final adjustment of valve events can never be

reached except by actual trial. So far as lead is concerned, from 1/16 to ⅛-inch for cylinders of the size mentioned would be values promising satisfactory operation. Regarding compression, the most satisfactory results are usually reached with exhaust closure from 10 to 15 percent of the stroke in advance of the end; that is, with compression extended over from 10 to 15 percent of the stroke. If differences are made between the cylinders, then the closure may be made earliest in the L.P., next in the I. P., and latest in the H. P. The closure of the exhaust valve at 10 to 15 percent of the stroke from the end will correspond to closure at a crank angle of 35 to 45 degrees before the end of the stroke.

Q. 353.—Would you please state what, in your opinion, should be the size of a receiver, that is the ratio of volume of the receiver to that of the cylinder exhausting into it, of a fore-and-aft marine compound engine, cranks at right angles, H. P. leading, the work to be evenly divided between the two cylinders, ratio of cylinders 4 to 1, number of expansions from 6 to 8, condensing type, boiler pressure 150 pounds. J. G. R.

A.—The size of the receiver of a compound engine affects chiefly the amount of drop at the opening of the H. P. exhaust, and the fluctuation of pressure on the H. P. exhaust and L. P. intake up to point of cutoff. The size of receiver has but slight influence on the distribution of work between the two cylinders, this latter requirement being chiefly determined by the point of L. P. cutoff. If you are not already familiar with the fact, a little thought will show you that the earlier the cutoff in the L. P. the more work will it develop as compared with the H. P.; and *vice versa*, the later the cutoff in the L. P. the less work will it develop as compared with the H. P. For the actual volume of the receiver in the case you mention, it should be somewhat greater than that of the H. P. cylinder. An excess of from 20 to 50 percent would give receiver volumes from which, with suitably adjusted L. P. cutoff, good results might be expected.

Q. 360.—(1) After years of service, I find that the crank shaft on a marine engine has worked its way into the journal brasses so far as to affect the clearance at bottom end of cylinder. What would you do in this case?

(2) Please explain direct and indirect valve and where indirect valves are generally used?

(3) Why are some valves constructed so that they take steam in the middle instead of at the ends?

(4) Please explain open and closed eccentric rods and the effect of the latter on the valve when "linking up." O. H. P.

A.—(1) Either block up the journal brasses or put in new ones. The gradual drawing of the piston toward the bottom end of the cylinder in its stroke is due to taking up for wear constantly in one direction. In the case you mention, the pillow block cap and upper brass presumably followed down as the shaft descended, all adjustment and takeup being made downward instead of alternately downward and upward, as should have been the case. If now the lower brasses cannot be blocked or wedged up so as to bring back the shaft to its original position, then new brasses should be provided.

(2) We are not sure what you mean by direct and indirect valve. In the ordinary valve gear the motion proceeds direct from the eccentric to the valve stem. In certain cases an intermediate rock-shaft is used with arms in opposite directions, in such manner as to reverse the relative motion of the valve and eccentric, and thus call for a different setting of the eccentric in the two cases. With a direct motion, the eccentric leads the crank by something more than 90 degrees, the excess over 90 degrees being commonly called the angular advance. For similar valve movement with the indirect or reversed motion the eccentric is directly opposite to its position for the direct gear, thus bringing it behind the crank by something less than 90 degrees, the shortage from 90 degrees being the same in amount as the so-called angular advance in the direct gear.

The terms direct and indirect are sometimes applied to valve gears rigged in these two ways. The purpose of this indirect or reversed arrangement is usually to bring the valve and valve chest to a different side of the cylinder from where it would naturally be found with the direct gear. With the latter, the valve chest is naturally forward or aft of the cylinder. By the use of the rock-shaft, as may be readily seen, the valve chest may be brought to the side of the cylinder, starboard or port, and thus in a way realize one of the features of the radial type of valve gear.

(3) It is mainly a matter of convenience, depending largely upon the placing of the steam and exhaust pipes with reference to the mid-position of the valve.

(4) Eccentric rods are "closed" or "open" according to whether they cross each other in an irregular × or not. When closed or "crossed," the effect of linking up is to decrease the equivalent eccentric throw, the valve travel, the port opening and the lead; to increase the angular advance; and to bring the cutoff earlier in the stroke.

Q. 362.—Will you kindly let me know what the "valve travel" is in both H. P. and L. P. cylinders of the compound engine 6 and 12 by 10 inches shown in the October, 1906, number, pages 393-398? M. F. G.

A.—We are informed by the designer of this engine that the valve travel in each cylinder is 1½ inches.

Q. 364.—Under what circumstances would it be considered economical to run a compound condensing engine single? Subscriber.

A.—It would scarcely be considered economical to run such an engine in the manner described, although it might be readily conceivable that necessity should dictate such operation. For instance, if either cylinder should become damaged in any way, and could be cut out from the steam circuit, then the other cylinder would have to be utilized to run the engine. If for any reason the boiler pressure available should be very much lower than normal, it might be found advisable to run with a single cylinder instead of attempting to expand through the two cylinders. In general, however, such a procedure will be the reverse of economical.

Q. 365.—A wooden schooner is to be designed carrying a cargo of 100 tons; seven people with luggage; a motor of about 3 tons.

(1) What will be the exact displacement?

(2) What will be the best general dimensions?

(3) What will be the required brake horsepower for a speed of 4½ knots? Jap.

A.—No exact displacement can be specified, because no two designers would solve the problem in exactly the same way. It may be said in general that a wooden vessel of this character, carrying a load such as specified, might have a displacement of anywhere from 200 to 350 tons, or more, depending upon a variety of considerations too numerous to specify here. The best general dimensions would depend altogether upon the service for which she was designed, and cannot well be specified in advance of a full knowledge of the conditions of the case. The vessel with a displacement of 200 tons would probably have a length of about 90 feet, while a displacement of 350 tons would call for a length of 110 or 115 feet. The power required for a speed of 4½ knots is another item which cannot be stated without knowing the remaining elements of the problem, but may be roughly placed between limits of 25 and 40 horsepower for the two displacements mentioned.

Q. 366.—We are desirous of obtaining data regarding the height of funnels above the grate in modern liners, also at what height the funnel stands above the waterline. T. P. C.

A.—We have ascertained from our own files the following heights of funnels above grates:

Deutschland (Hamburg-American Line)	105 feet
Pennsylvania (Hamburg-American Line)	98 feet
Kronprinz Wilhelm (North German Lloyd)	110 feet
Kaiser Wilhelm der Grosse (North German Lloyd) (above keel)	106 feet
La Provence (French Line)	115 feet
Vaderland (Red Star Line)	98 feet
Umbria (Cunard Line)	85 feet
Korea (Pacific Mail)	108 feet

The heights above waterlines would be from 20 to 25 feet less in each case.

TECHNICAL PUBLICATIONS.

The Steel Square as a Calculating Machine. By Albert Fair. Size, 5 by 7½ inches. Pages, 81; illustrations, 37. New York, 1906. The Industrial Publication Company. Price, 50 cents.

This book has been prepared for the ordinary workman in the shop, and gives particulars of the solution by means of a common steel square of a great number of problems in all branches of mechanics. This novel use of a tool familiar to all mechanics enables one to lay out work with an ease and accuracy scarcely credible without making the attempt. The explanations of the problems presented are clear and simple, so that a boy could understand them. The work should recommend itself to all those who have occasion to use the square.

The Mechanical World Pocket Diary and Year Book for 1907. Twentieth annual issue. Size, 4 by 6¼ inches. Pages, 302; figures, 73. Manchester. Emmott & Company, Ltd. Price, 6d, net.

Within a small compass, in a book conveniently carried in the pocket, have been collected a large number of tables of engineering data of all descriptions, from the usual mathematical and trigonometrical tables to horsepower, steam, and vacua tables, tables of the properties of I- and Z-bars, shafting and the strength of materials, electrical constants and wiring tables, hydraulic data, tables of bolts, nuts and threads, conversion tables between metric measures and the corresponding British units—in short, all of the usual data and tables to be found in the general engineering reference books. In addition to this are to be found many "chapters" or notes on various subjects of an engineering character, such as engines, boilers, valve setting, pumps, oil and gas engines, belt and rope driving, electric machinery, power transmission and devices, and a multitude of other items of interest to the engineer.

In the rear of the book are a diary and blank pages for memoranda. A splendid and very complete index renders the book exceedingly easy of access, and adds enormously to its value as a work of ready reference.

Die Schiffsschraube, Part II. By Albert Achenbach. Size, 6½ by 9½ inches. Pages, 152; folding plates, 20. Kiel, 1906. Robert Cordes.

This is the second of the three volumes upon this general subject, and includes details of construction of ship's propellers, with an appendix upon the propulsive outfit of motor boats. The work is divided into seven chapters, of which the first treats in general of the constructive features; the second of the materials used for screw propellers; the third of details of construction of propellers for warships; the fourth of details for mercantile propellers; the fifth of patented propellers of the Niki type; the sixth of the development of a screw propeller with regard to the contour of the blades and their sections; while the seventh and last treats of the operations of constructing a propeller in the shop, including both the casting and the finishing.

The appendix, covering motor boat propellers, gives a good deal of detail concerning clutches and feathering propellers and outfits, and includes descriptions of a number of patented devices of various sorts intended for motor boat work.

The illustrations consist almost entirely of drawings to scale, and hence are of the highest value to designers and investigators. The text is in German, and is very well illustrated by the numerous drawings (206) mentioned.

Personals.

Wm. J. Harbottle, head draftsman in the marine department of Wigham Richardson & Company, Walker-on-Tyne, England, has been appointed manager of the mechanical and electrical departments of the De Beers mines, Kimberley, South Africa.

O. H. Taylor has been appointed passenger traffic manager, with temporary office on Pier 32, North River, New York, of the steamship lines operated by C. W. Morse, including the Mallory and Clyde Steamship Lines, the Eastern Steamship Company, the Metropolitan Line and the People's and Troy Lines on the Hudson river.

Henry H. Suplee, for many years technical editor of the *Engineering Magazine,* and James V. Colwell, recently works manager for the C. W. Hunt Company, have bought *Cassier's Magazine,* and will continue publication at 3 West Twenty-ninth street, New York. Mr. Suplee will take care of the editorial end, while the business department will be directed by Mr. Colwell.

The Power Specialty Company, of New York, announces the establishment of a branch office in the Land Title Building, Philadelphia, in charge of W. E. Dowd, Jr.

H. A. Flagg has been appointed sales manager in charge of the New York office of the Shelby Steel Tube Company.

D. M. Wallace, for the past twelve years chief naval architect of Caird & Company, Ltd., of Greenock, Scotland, has become a member of the firm of Wallace & Company, naval architects and consulting engineers, London.

Ernest Haliburton, of the Cunard Steamship Company, has been appointed to a vacancy on the Board of the Peninsular & Oriental Steam Navigation Company.

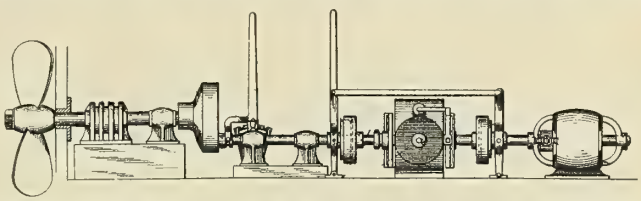
James A. Rees has been appointed sales manager of the Western Launch & Engine Works, Incorporated, Michigan City, Ind.

SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

830,011. MARINE PROPULSION AND LIGHTING. GEORGE G. SCHROEDER, WASHINGTON, D. C.

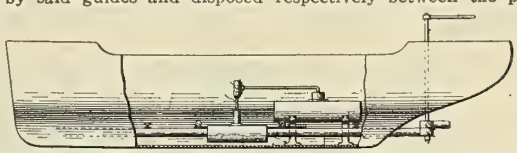
Abstract.—The object of the invention is to provide an engine of the rotary type which is adapted to have its shaft connected with the shaft of a rotary generator. The said generator is electrically connected with suitable storage batteries, which in turn are connected with lights used for illumination and for signaling. The shaft of the said engine is also adapted to be connected with the propeller shaft, and by this means rotary motion



is transmitted to the propeller. A suitable means of special construction is provided whereby the rotary movement to the propeller may be reversed. A system of levers and clutches is provided, which are so arranged that when the engine is thrown out of gear with the propeller it is at the same time thrown in gear with the generator, and vice versa. Eight claims.

830,356. PROPELLING AND STEERING MECHANISM FOR VESSELS. NELS P. NELSON, FOY, MINN.

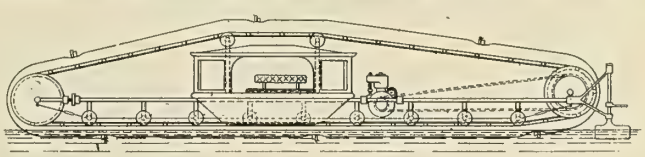
Claim.—2. Propelling mechanism for vessels comprising a flow-pipe having suction and discharge portions, a suction and discharge pump between such portions, guides upon the flow-pipe, swinging valves pivotally supported by said guides and disposed respectively between the pump and



suction and discharge portions, adjustable ported valve shells or casings coöperating therewith, said shells being provided with guide-slots for the passage of the guides, and means for adjusting said shells or casings to reverse the action of the valves and adapt either to serve as a suction and the other as a discharge valve. Three claims.

830,447. WATER-MOBILE. PATRICK F. MACCALLUM, GLASGOW, SCOTLAND, ASSIGNOR OF ONE-HALF TO ROBERT GRAY, GLASGOW.

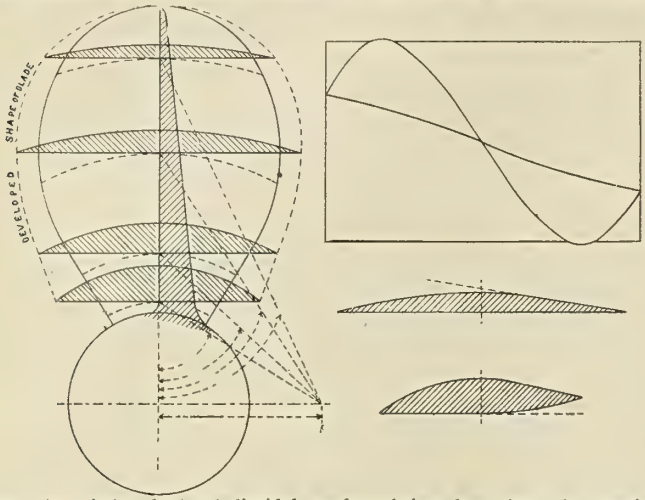
Claim.—2. In water-mobiles the combination with the framing and drums thereon of traveling pneumatic bands of semicircular section, the



inner flat surfaces being transversely stiffened, and the outer surfaces collapsible when passing round wheels or drums in combination with guide-rail belts affixed to the inner flat surfaces of the bands. Two claims.

832,173. SCREW-PROPELLER. DAVID W. TAYLOR, WASHINGTON, D. C.

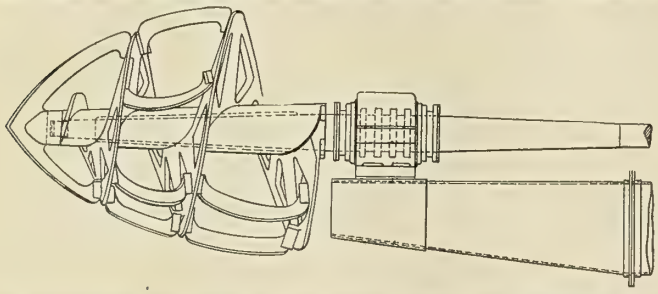
Claim.—1. A propeller blade in which the back of the blade is a true helicoid for at least one-fourth of the surface, from the forward



edge, the pitch of the helicoidal surface being less than the nominal pitch by an amount greater than the percentage of slip. Six claims.

832,345. DISINTEGRATOR FOR SUCTION-DREDGERS. HENRICUS P. A. J. SMULDERS, ROTTERDAM, NETHERLANDS.

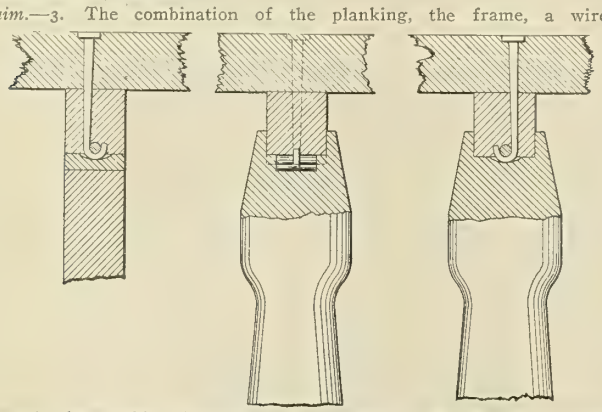
Claim.—1. A disintegrator for suction-dredgers comprising a conical helix fixed to the end of a revolving shaft which extends parallelly to



the suction-pipe, the turns of said conical helix thus passing in front of the entrance to said suction-pipe, said turns being provided with holes and with angular knives, so as to produce a thorough subdivision of the earth. Three claims.

832,435. CONSTRUCTION OF BOATS. BENJAMIN C. TUTHILL, WASHINGTON, D. C.

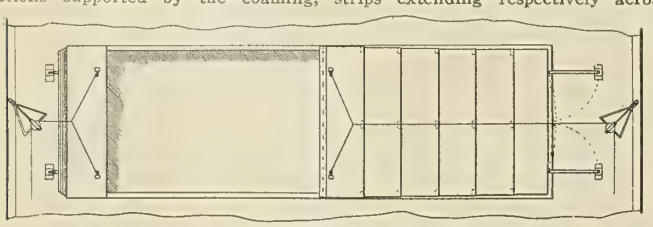
Claim.—3. The combination of the planking, the frame, a wire or



rod on the inner side of the frame extending in the direction of length of the frame, and a nail or rivet driven through the planking and frame and clenched around the wire or rod. Four claims.

833,058. HATCH-COVER FOR SHIPS. JOSEPH KIDD, DULUTH, MINN.

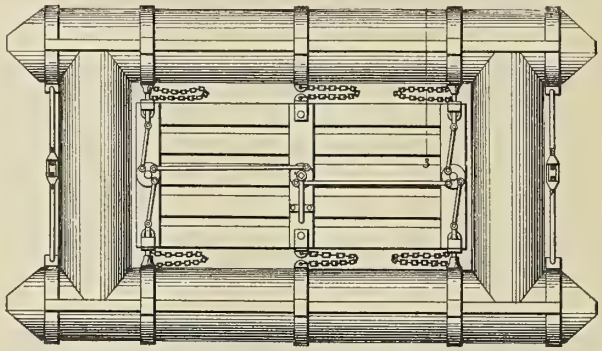
Claim.—7. The combination with a hatch-coaming, of telescoping sections supported by the coaming, strips extending respectively across



the upper and lower faces of said sections and having wedge-shaped faces and adapted to interlock with each other when in their extended position, and means for operating said sections. Nine claims.

833,000. LIFE-RAFT. PETER C. PETRIE AND HENRY L. DESANGES, NEW YORK.

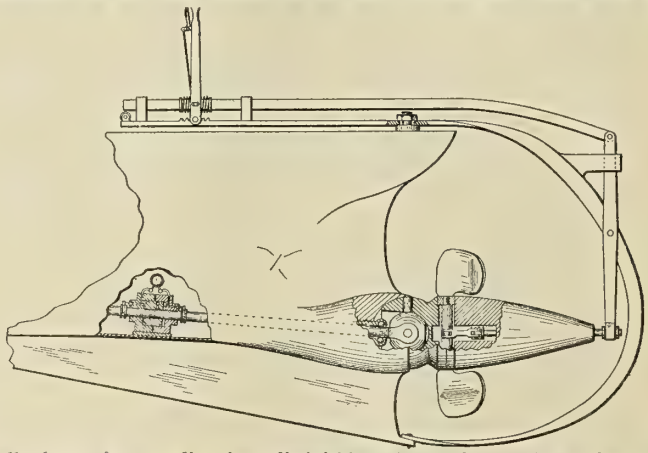
Claim.—1 A raft having a platform, means for suspending the plat-



form below the plane of the raft, and means for removably holding the platform within or approximately within the plane of the raft. Eight claims.

833,364. PROPELLER. JOSEPH A. ARTHUR, BRIDGEPORT, CONN.

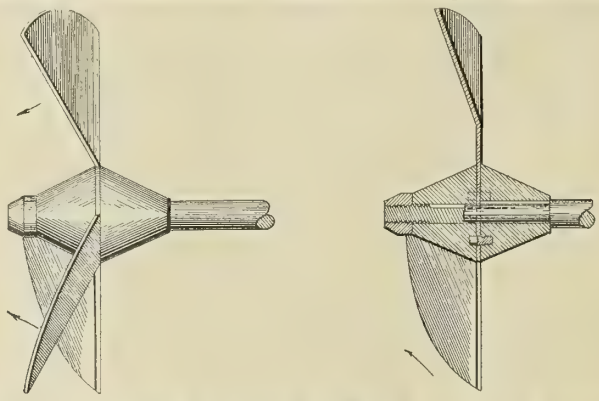
Abstract.—The invention consists in the use of a tapering shell by which "churning" of the water is prevented, and in the combination therewith of reversible blades or flukes journaled on suitable arbors or rock-shafts in the front portion of the shell, so that they rotate with the



shell always in one direction, diminishing the strain on the engine and connections, and may be swung by suitable means to reverse them and drive the vessel in the opposite direction or to change their inclination with reference to the water more or less, ("feathering,") so that their inclination and the speed of the vessel may be easily and properly proportioned to their speed of rotation. Nine claims.

833,586. PROPELLER. JOSEPH CROWTHER, DALLAS, OREGON.

Claim.—1. A propeller-wheel consisting of a two-part hub, flat blades



having angularly-disposed flat wings, the blades being clampedly arranged and secured between the two parts of the hub. Two claims.

The Steamship Empress of Ireland.

A correspondent informs us that the cylinder diameters and stroke given at page 338 of our September number are incorrect. The figures he gives us show cylinders 36, 52, 75 and 108 inches in diameter, with a common stroke of 69 inches. The power is about 18,000 at 81 revolutions per minute. He also advises us that instead of having two condensers for each engine, as stated at page 338, there is only one condenser for each set of engines, or two in all.